SECTION I
GENERAL INFORMATION

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Appendix B ZOLL 1600 Operator's Guide

SAFETY CONSIDERATIONS

WARNINGS

- The following is a list of service related safety considerations. For operation related safety consideration see the ZOLL 1600 Operator's Guide. Service Technicians should be aware of all safety considerations prior to servicing the equipment.
- **THE ZOLL 1600 DEVICE SHOULD BE SERVICED BY QUALIFIED PERSONNEL ONLY!** Unauthorized persons should not attempt to service this device.
- This device can generate up to 6000 volts with sufficient current to cause lethal shocks. Please read carefully all the material contained herein before attempting service.
- Do not discharge with electrodes shorted together or in open air.
- All persons near the equipment must be warned to "STAND CLEAR" prior to discharging the defibrillator.
- Limit internal discharges to 100 Joules or less. Do not discharge the unit more than 3 times in one minute or damage may result.
- Follow the recommended checkout procedures in Section II to ensure optimum operation of the ZOLL 1600 device. Be sure to make thorough visual inspections, especially on cables and wires. Broken or frayed wires may cause interference or loss of signal.
- Do not discharge a PD™ 4410 battery pack except in a Base PowerCharger^{4x4} or compatible ZOLL Battery Charging/Testing device.
- Federal (U.S.A.) law restricts this device to use by or on the order of a physician.
- Safety and effectiveness data submitted to the Food and Drug Administration (FDA) under section 510(K) of the Medical Device Act by ZOLL Medical Corporation to obtain approval to market is based upon the use of ZOLL accessories such as disposable electrodes, patient cables and batteries. The use of external pacing/defibrillation electrodes and adapter devices from sources other than ZOLL is not recommended. ZOLL makes no representations or warranties regarding the performance or effectiveness of its products when used in conjunction with pacing/defibrillation electrodes and adapter devices from other sources. If device failure is attributable to pacing/defibrillation electrodes or adapter devices not manufactured by ZOLL, this may void ZOLL's warranty.

- Proper operation of the ZOLL 1600, together with correct electrode placement is critical to obtaining the optimum results. The operator must be thoroughly familiar with proper ZOLL 1600 operation.
- Do not use the ZOLL 1600 in semiautomatic mode during patient movement on a stretcher or in an ambulance or other conveyance. A patient must be motionless during ECG analysis. Do not touch the patient during analysis. Cease all movement of stretcher or vehicle before analyzing the ECG. If using the device in an emergency vehicle, bring the vehicle to a halt before using the ZOLL 1600 in semiautomatic mode.
- The ZOLL 1600 is protected against interference from radio frequency emissions typical of two-way radios and cellular phones (digital and analog) used in emergency service/public safety activities. Users of the ZOLL 1600 should assess the device's performance in their typical environment of use for the possibility of radio frequency interference from high-power sources. Radio Frequency Interference (RFI) may be observed as shifts in monitor baseline, trace compression, or transient spikes on the display.
- Keep a fully charged spare battery pack with the ZOLL 1600 at all times. Replace the battery immediately when a low battery message is displayed.
- Emergency defibrillation should be attempted only by appropriately trained, skilled personnel who are familiar with equipment operation. Training appropriateness, such as Advanced Cardiac Life Support (ACLS) or Basic Life Support (BLS) certification, should be the determination of the prescribing physician.
- Synchronized cardioversion should only be attempted by skilled personnel trained in Advanced Cardiac Life Support (ACLS) and familiar with equipment operation. The precise cardiac arrhythmia must be determined before attempting defibrillation.
- Prior to attempting to perform a sychronized cardioversion, ensure that the ECG signal quality is good to minimize risk of sychronizing on artifact.
- Only Qualified Personnel should disassemble the ZOLL 1600. A shock hazard exists. Refer all problems to ZOLL Technical Service.
- **Follow all recommended maintenance instructions. If a problem occurs, obtain service immediately. Do not use the ZOLL 1600 until the unit has been inspected by the appropriate personnel.**

Operator Safety

- Do not use the ZOLL 1600 in the presence of flammable agents (such as gasoline), oxygen-rich atmospheres, or anesthetics. Using the instrument near the site of a gasoline spill may cause an explosion.
- Do not discharge with paddles or electrodes shorted together or in open air. Stand clear of patient when defibrillating.
- Warn all persons in attendance of the patient to STAND CLEAR prior to defibrillator discharge.
- Do not use the instrument near or within puddles of water.
- Do not touch patient, or any equipment connected to the patient other than the defibrillator during defibrillation.
- Do not allow electrolyte gel to accumulate on hands.
- Do not touch the gelled area of the electrodes while pacing.
- Excessive body hair or wet, sweaty skin may interfere with electrode adhesion. Remove the hair and/or moisture from the area where the electrode is to be attached.
- Do not discharge the defibrillator except as indicated in the instructions. Do not discharge the defibrillator if the electrodes are not properly placed on the patient.
- The user must check that the equipment functions properly and see that it is in proper condition before being used.
- Disconnect any other medical electrical equipment that is not specifically defibrillation protected from the patient prior to defibrillation.

Patient Safety

- Do not defibrillate pediatric patients (weighing less than 80 lbs./36 kg) in semiautomatic mode (AHA standard).
- The ZOLL 1600 detects ECG electrical signals only. It will not detect a pulse. Always verify rate and pulse by physical assessment of the patient. Never assume a rate display indicates a patient has a pulse.
- Use only high quality ECG electrodes. ECG electrodes are for rhythm acquisition only. Defibrillation or pacing cannot be accomplished with ECG electrodes.
- Do not use electrodes with gel that is torn or split from the foil.
- Multi-Function electrodes should be used no longer than eight (8) hours for continuous pacing.
- Pacer output current (mA) must be set to 0mA when connecting and disconnecting a patient from the ZOLL 1600.

- Prolonged pacing (in excess of 30 minutes), particularly in neonates and adults with severely restricted blood flow, may cause burns. Periodic inspection of the underlying skin is recommended.

- Internal implanted pacemakers may cause the heart rate meter to count the pacemaker rate during incidents of cardiac arrest or other arrhythmias. Pacemaker patients should be carefully observed. Check the patient's pulse; do not rely solely on heart rate meters. Dedicated pacemaker detection circuitry may not detect and display all implanted pacemaker spikes; patient history and physical exam are important in the determination of the presence of an implanted pacemaker.

HOW TO USE THIS MANUAL

Who it is for

The *ZOLL 1600 Service Manual* is a basic technical reference document designed for biomedical engineering personnel whose responsibilities include maintenance and repair of medical equipment.

Purpose

Its purpose is to provide the basic information needed to allow biomedical engineering personnel to identify malfunctions and/or repair the ZOLL 1600 to the sub-assembly (printed circuit board) level.

Recommended Use

The *Service Manual* should be readily available in the facility's equipment maintenance library. It will be used for preventive maintenance checks and for troubleshooting when problems are reported.

The *Operator's Guide* will be used in training new operators and for operational reference. This copy should be kept with the ZOLL 1600 Service Manual. A separately bound copy should be kept with the ZOLL 1600 device.

The *Service Manual* consists of several key sections:

Section I: General Information

This section contains a number of important notices and reference material, including safety warnings and ZOLL's warranty statement. **Be sure to review this section thoroughly before attempting to use or service the ZOLL 1600 device.**

Section II: Checkout Procedures

This section contains the recommended six-month checkout procedures for the ZOLL 1600 unit. This procedure should be used routinely to ensure that the unit is operating within specifications.

For daily checks and procedures, see the Operator's Manual.

Section III: Troubleshooting Guides

This section contains an operational troubleshooting section, one for use by non-technical personnel to respond to common problems detected during ZOLL 1600 operational use.

Section IV: Functional Descriptions

This section provides a basic technical description of the ZOLL 1600's subassembly modules. The information should be thoroughly reviewed before servicing.

Section V: Schematic Drawings

Major circuit board schematics are included for troubleshooting purposes.

Section VI: Component Layout Drawings

Major component layout drawings are included for troubleshooting purposes.

Section VII: Disassembly Procedures

Step-by-step instructions are provided for removing subassemblies in the event of failure. Refer to the Service Policy in Section I for return and repair information.

Section VIII: Replacement Parts

This section contains a detailed listing of ZOLL part numbers for field replaceable parts available for the ZOLL 1600 and will allow the service person to identify and order replacement parts. No attempt to replace parts at the component level should be attempted or the ZOLL warranty may be voided.

Appendix A: Calibration / Adjustment Procedure & Manufacturing Configuration Procedure

This section allows properly trained service technicians to check and adjust the Intensity Calibration, the X-Axis Calibration, the Y-Axis Calibration, and the Impedance Measurement of the ZOLL 1600 any time a module is replaced in the ZOLL 1600.

The Manufacturing Configuration Procedure explains how to program the System and Medical Reporting Module (MRM) serial numbers into the ZOLL 1600. This is performed after the Digital or MRM boards are replaced.

Appendix B: ZOLL 1600 Operator's Guide

The *Operator's Manual* has been reproduced here for convenience and consistency. It should be read and understood before attempting any service procedure.

Symbols used on the equipment

Any or all of the following symbols may be used in this manual or on this equipment:

Type BF patient connection.

Type CF patient connection.

Defibrillation protected Type BF patient connection.

Defibrillation protected Type CF patient connection.

DANGER High voltage present.

ATTENTION Refer to manual for more information.

Fusible link.

Protective (earth) ground terminal.

Alternating Current

DANGER Risk of explosion if used in the presence of flammable anesthetics.

SERVICE POLICY

WARRANTY

In North America: Consult your purchasing agreement for terms and conditions associated with your warranty.

Outside of North America: Consult ZOLL authorized representative.

In order to maintain this warranty, the instructions and procedures contained in this manual must be strictly followed.

For additional information, please call the ZOLL Technical Service Department at

1-800-348-9011	in North America
1-781-229-0020	outside of North America

SERVICE

The ZOLL 1600 devices will provide trouble free operation without periodic recalibration or adjustment. However, it is recommended that the biomedical engineering department perform routine tests of the device to verify proper operation. (See Section II.)

U.S.A. customers

Should the ZOLL 1600 require service, contact the ZOLL Technical Service Department to obtain a return claim number. The unit should be returned, in its original container, to:

ZOLL Medical Corporation
32 Second Avenue,
Burlington, Massachusetts 01803-4420,
Attn: Technical Service Department

Loaner instruments are available for use while repairs are being completed. To request loan equipment, contact ZOLL at 1-800-348-9011 (in Massachusetts: 1-781-229-0020).

Please have the following information available to expedite service:

- Unit serial number
- A description of the problem
- Department where equipment is in use
- Sample ECG strips documenting problem (if available)
- A Purchase Order to allow tracking of loan equipment
- A Purchase Order for systems out of warranty

International Customers

Should the ZOLL 1600 require service, it should be returned, in its original container, to the nearest authorized ZOLL Medical Corporation service center. To determine which authorized ZOLL Medical Corporation service center to use, write, call or fax:

ZOLL Medical Corporation
32 Second Avenue,
Burlington, Massachusetts 01803-4420, USA
Attn: International Sales Department

1-781-229-0020 (voice)
or
1-781-272-5443 (International Fax)
Attn: International Sales Department

SECTION II
CHECKOUT PROCEDURES

Resuscitation equipment must be maintained ready for immediate use. There are two checkout procedures:

- **Daily test routine** - can be completed in a few minutes and requires no additional test equipment. The daily checkout procedure can be found in the Operator's Guide (Section 6)
- **Extensive, six-month testing sequence** - verifies proper operation for each of the ZOLL 1600/1700 major functions.

Preventive maintenance test sequences are also described in Section 6, **Recommended Daily Checkout** in the *Operator's Guide*.

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10. MRM Tests II-24

Six-Month Checkout Procedure Data Sheet **II-26**

Six-Month

Checkout Procedure

for the

ZOLL 1600 / 1700

This procedure and checklist are intended for technical personnel and require the use of additional tools and equipment.

COPY **THE CHECKLIST FORM BEFORE USE!!**

If a problem is discovered during the checkout procedure, use the Troubleshooting Guides in Section III to isolate or resolve the problem.

For additional assistance, contact ZOLL Technical Service Department.

SIX-MONTH CHECKOUT PROCEDURE

This section of the ZOLL 1600/1700 Service Manual contains a series of checkout procedures to be performed by technical personnel on a routine basis (recommended for six-month intervals) to ensure quality operation of the ZOLL 1600/1700 device. Some tests require specialized testing equipment and trained personnel. Each test sequence lists the tools required and the frequency with which the test should be performed.

ZOLL recommends that a routine testing procedure be established for your ZOLL 1600/1700 based on the forms supplied in this section.

TESTING NOTES

- Be sure to complete all actions for a **Step** before looking for results.
- In the **Look for** column on the Checkout Procedure Data Sheet is a description of the action that should occur. Circle the appropriate result **(YES or NO)** in the **Circle the Result** column.

For troubleshooting information, refer to Section III in this manual.

Recommended Six-Month Checkout Procedure II-2

Manual Mode Procedure II-4
1. Initialize Tests II-5
2. Leakage Tests II-7
3. Diagnostics Mode Tests II-9
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Recommended Six-Month Checkout Procedure Data Sheet II-26

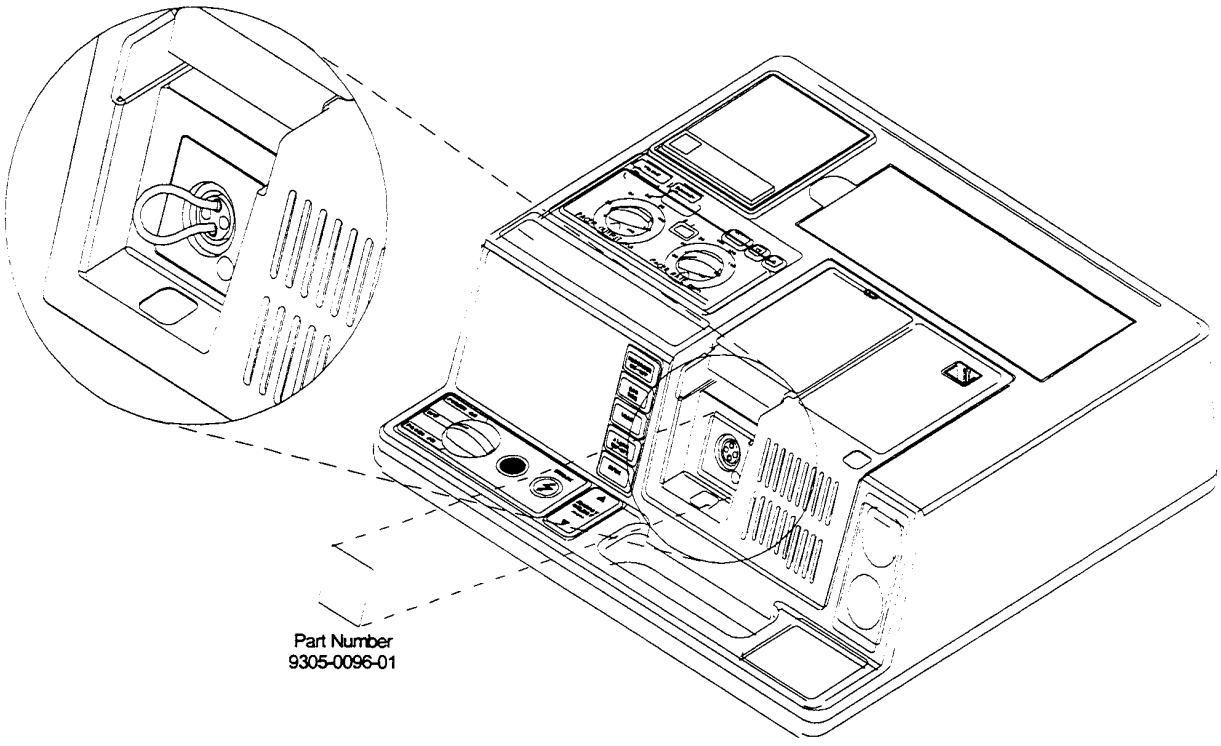
MANUAL MODE PROCEDURE

This section does not apply to MANUAL ONLY devices.

All devices without a Manual Key Switch can be put into Manual Mode by following the steps below:

Unit should be off.

- Peel label part number 9305-0096-01 off of the ZOLL 1600/1700 device. (See Diagram below).
- Turn the **SELECTOR SWITCH** to **POWER ON**. Listen for four (4) beeps.
- Strip back approximately ¼" of insulation on both ends of an insulated wire.
- Place the ends of the insulated wire into the two brass barrel connectors and remove. (See diagram below)
- Repeat the previous step to Confirm Manual Mode operation.
- If the label cannot be affixed onto the ZOLL 1600/1700 device after removal, additional labels can be ordered by calling ZOLL Medical Corporation at 1-800-348-9011.



1. INITIALIZE TESTS

The Initialize Test verifies that the ZOLL 1600/1700 unit is:

- electrically connected to a ZOLL PD™ 4410 battery or PowerCharger™
- LEDs, sensors, and message codes are operating
- recorder paper is properly installed
- date and time is shown on the stripchart.

1.1 INITIALIZATION

SEMI-AUTOMATIC DEVICES

(MFE Cable must be installed in the unit. No memory card should be installed in the unit.)

- Turn SELECTOR SWITCH to POWER ON.
- Listen for a 4 beep audible tone.
- Listen for "CHECK MEMORY CARD" voice prompt. If no voice prompt is heard check with your Medical Control Authority to determine actual device configuration.
- Mark the Checkout Procedure Data Sheet.

MANUAL ONLY DEVICES

(MFE Cable must be installed in the unit. No memory card should be installed in the unit.)

- Turn SELECTOR SWITCH to POWER ON.
- Listen for several audible tones.
- Look for "INSERT CARD" on the display.
- Mark the Checkout Procedure Data Sheet.

1.2 RECORDER CHECK (If Recorder is Installed)

- Make sure there is no paper in the paper well.
- Press the **RECORDER ON-OFF** button.
- "NO PAPER" message is displayed.
- Mark the Checkout Procedure Data Sheet.
- Put a roll of paper in the paper well.
- Press **RECORDER ON-OFF** button.
- "NO PAPER" message is removed and recorder operates correctly.
- Mark the Checkout Procedure Data Sheet.

1.3 SET THE CORRECT DATE AND TIME (if necessary)

Unit should be turned off.

- Press and hold the **SET** button while turning the unit to **POWER ON**.
- Use the **SET** up arrow (▲) and down arrow (▼) buttons to set the DATE. (Refer to the Operator's Manual.)
- Press **SET** again to input that date.
- Repeat the last two steps for the MONTH, YEAR, and TIME of DAY.
- Press **SET** again.

- Turn off the unit. Wait 5 seconds.
- Turn the unit to **POWER ON.**

1.4 DATE AND TIME CHECK (If Recorder is Installed)

- Press the **RECORDER ON-OFF** button to get a print-out on the recorder paper of the date and time.
- Verify that the date and time are correct.

2. LEAKAGE TESTS

EQUIPMENT REQUIRED:

- 1 red miniature alligator-to-miniature alligator test lead.
- 2 black miniature alligator-to-miniature alligator test leads.
- leakage tester.
- Test not required for battery ONLY operated equipment.

CAUTION

- BE SURE TO CONNECT BATTERY PROPERLY OR DAMAGE TO UNIT MAY RESULT

2.1 TEST SETUP

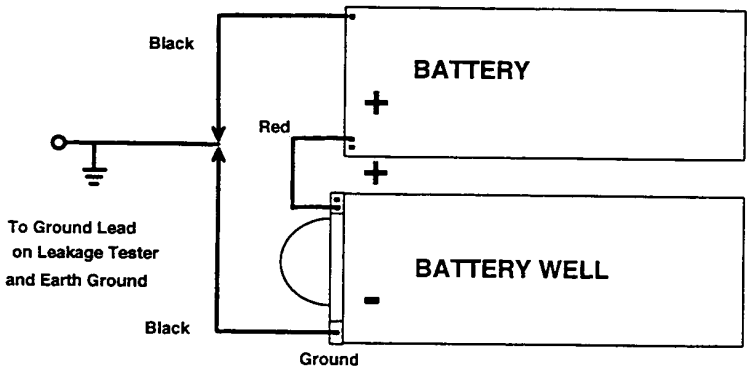
Use the PowerCharger™ to provide AC power and ground for leakage measurements.

Note: Use metal edge of A/C PowerCharger for grounding purposes.

If a PowerCharger™ is unavailable, perform the following steps.

Unit should be off.

- Connect one end of black lead to the ground terminal in battery well.
- Connect other end of black lead to second black lead.
- Connect other end of second black lead to "–" terminal socket of the battery.
- Connect red lead to "+" terminal socket of the battery.
- Connect other end of red lead to "+" terminal in battery well.
- Connect leakage analyzer ground lead to junction formed by two black leads.
- Turn unit to **POWER ON**.



2.2 MAXIMUM LEAKAGE ACCEPTANCE LIMITS ARE AS FOLLOWS:

MAXIMUM LEAKAGE ACCEPTANCE LIMITS

ECG Leads to Ground	10 μA
Risk Current with patient ECG Cable	20 μA
Risk Current without patient ECG Cable	10 μA
MFC leads to ground	100 μA
MFC risk current	100 μA

3. DIAGNOSTICS MODE TESTS

NOTE: Section 3 tests are to be performed only on ZOLL 1600/1700 units, which are equipped with the optional Pacing function.

3.1 ENTER DIAGNOSTICS MODE

To power up the ZOLL 1600/1700 in extended diagnostics mode:

- Press and hold the **SYNC** button for at least 7-10 seconds (until 5 beeps total are heard) while turning the **SELECTOR SWITCH** to **POWER ON**.
- The battery voltage will be displayed on CRT as "XXXV" (for example, "100V", which means 10.0 volts).

3.2 TEST PROCEDURE

- Turn the **SELECTOR SWITCH** to **PACER ON**.
- Turn the Manual Key/Manual overide switch clockwise (to 3 o'clock position) and release.
- Turn the key clockwise/Manual overide switch (to 3 o'clock position) again within 5 seconds to confirm **Manual Mode** Operation.
- Set **RATE** control to 30 (full CCW), 80, 180 pulses per minute (ppm).
- Check that the CRT displays those values +/-8 ppm.
- Mark the Checkout Procedure Data Sheet

3.3 TEST PROCEDURE

- Set the **OUTPUT** to 20, 80, 140 mA.
- Verify that the CRT displays those values +/-8 mA.
- Mark the Checkout Procedure Data Sheet.

4. POWER SUPPLY TESTS
(OPTIONAL DIAGNOSTIC TEST)

EQUIPMENT REQUIRED:

- 2 red miniature alligator-to-miniature alligator test leads.
- 1 black miniature alligator-to-miniature alligator test lead.
- Hewlett-Packard HP 63286A DC power supply or equivalent. (10 Amp minimum)
- 0.1Ω 1% Resistor, 1/4w or greater.
- 1000Ω 1% 1/4w resistor.
- Fluke 75 multimeter or equivalent.

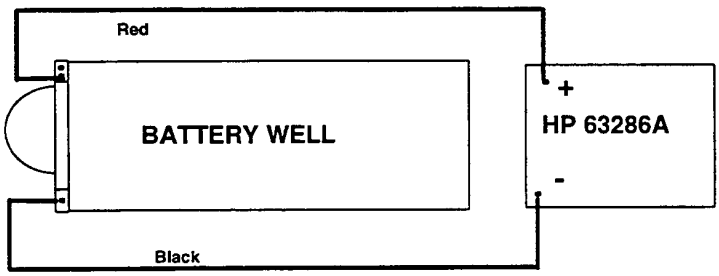
CAUTION:

- BE SURE TO CONNECT BATTERY PROPERLY OR DAMAGE TO UNIT MAY RESULT
- DO NOT RAISE THE POWER SUPPLY VOLTAGE > 12V

4.1 TEST SETUP

Unit should be off.

- Connect one end of the black lead to the ground terminal in battery well.
- Connect the other end of black lead to the "–" terminal of the power supply.
- Connect red lead to "+" terminal socket of the battery well.
- Set power supply voltage to 7V.
- Connect the other end of the red lead to the power supply.



4.2 TEST PROCEDURE

- Turn unit to **POWER ON**. It should not turn on.
- Turn off unit.

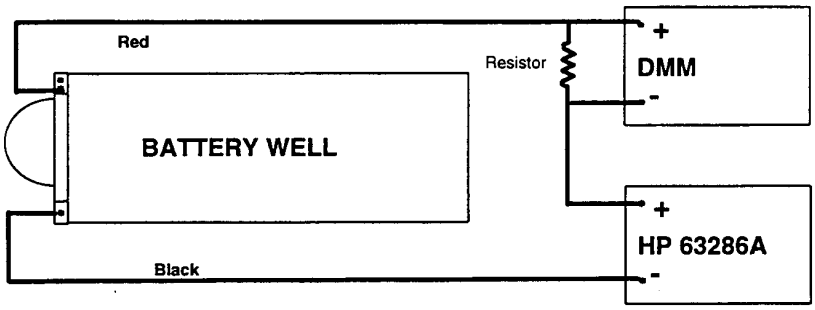
- Adjust power supply voltage to 9.3V.
- Turn unit on. It should now turn on.
- Mark the Checkout Procedure Data Sheet.

4.3 SHUT DOWN VOLTAGE TEST

- Keep voltage set at 9.3V. "LOW BATTERY" should be displayed within 30 seconds.
- Set voltage to 8.75V. Unit should shut off within 30 seconds.
- Turn off unit.
- Mark the Checkout Procedure Data Sheet.

4.4 TEST SETUP

- Remove red lead from power supply and connect to 0.1Ω resistor.
- Connect other end of resistor to "+" terminal of power supply.
- Connect multimeter across the resistor.
- Set voltage scale (if DVM is not autoranging) to 200 mV.



4.5 SYSTEM CURRENT TEST

- Set power supply to 10V.
- Set **SELECTOR SWITCH** to **POWER ON**, MFE cable should not be installed and "CABLE FAULT" should be displayed on the monitor.
- Voltage across resistor should be 120 mV or less (<1200 mA of ON current).
- Turn unit off.
- Mark the Checkout Procedure Data Sheet.

4.6 TEST SETUP

- Remove 0.1Ω resistor and replace with 1KΩ.
- Connect DMM across resistor.
- Set voltage scale to 200 mV.
- Measure voltage across resistor.

4.7 OFF LEAKAGE CURRENT TEST

- Measure across resistor with unit off.
- Voltage should be less than 170 mV (<170 μA of leakage current.)
- Mark the Checkout Procedure Data Sheet.

5. ECG TESTS

EQUIPMENT REQUIRED:

- Calibrated ECG simulator with 60Hz sine wave output capability.
- Oscilloscope with probes.
- Mini-phone plug for measuring output signal from **1 Volt ECG OUT** jack.
- ECG Cable

5.1 TEST SETUP

- Turn the **SELECTOR SWITCH** to **POWER ON**.
- Turn the Manual Key/Manual overide switch clockwise (to 3 o'clock position) and release.
- Turn the key clockwise/switch (to 3 o'clock position) again within 5 seconds to confirm **Manual Mode** Operation.
- Set to lead I.
- Connect the ECG leads to the simulator and to the ZOLL 1600/1700 device.
- Set the ECG Simulator to: BPM = 120, AMPLITUDE = 1 mV.
- The Heart Rate display should read 120 +/- 2 bpm.
- Repeat for Lead II and III

5.2 TEST PROCEDURE

- Break each ECG lead sense line by removing each of the three leads one at a time from the simulator.
- "ECG LEAD OFF" should be displayed on lower half of the monitor with the removal of each of the leads, and a dashed base line.
- Repeat step **5.2** for Leads II and Lead III.
- Mark the Checkout Procedure Data Sheet.

5.3 VOLUME CONTROL TEST PROCEDURE

- Press the **VOLUME** down (▼) button 5 times. No sound should be heard.
- Press the **VOLUME** up (▲)button.
- QRS Detection Tone should increase in volume to an acceptably high limit.
- Mark the Checkout Procedure Data Sheet.

5.4 TEST PROCEDURE

- Set **LEAD** to I and **ECG SIZE** to 1x.
- Step the **ECG SIZE** button through each setting.
- The display should change to reflect each size change.
- Mark the Checkout Procedure Data Sheet.

5.5 TEST PROCEDURE

- Set **LEAD** to I and **ECG SIZE** to 1x. If using a DYNATECH Nevada Impulse 4000, set the 1600/1700 to Lead II.
- Set an oscilloscope as follows:

  0.5 Volts per division.

  0.2 Seconds per division.
- Plug in the mini-phone plug to the ZOLL 1600/1700 device's **1 Volt ECG OUT** jack.
- Connect the scope probe to the terminals of the mini-phone plug.
- The QRS complex display should appear on the oscilloscope having an amplitude of 1 Volt +/- 0.2 V p-p.
- Mark the Checkout Procedure Data Sheet.

5.6 TEST PROCEDURE

- Set **ECG SIZE** to 1x.
- Press the **RECORDER ON/OFF** button.
- Press and **HOLD** the **SET** UP (▲) and DOWN arrow (▼) buttons to activate the calibration signal.
- The strip chart should display a signal of 120 ppm with an amplitude of 10 mm +/- 1 mm.
- Mark the Checkout Procedure Data Sheet.

5.7 NOTCH FILTER TEST PROCEDURE

- With the ZOLL 1600/1700 device in MANUAL mode, set to LEAD I, size 3x: apply a 1 mV p-p 60Hz sine wave from the simulator to the ECG input. Note: For 50Hz-configured units, input a 50Hz sine wave.
- Verify that the waveform on the recorder print-out is less than 1.5 mm.
- Mark the Checkout Procedure Data Sheet.
- Turn the ECG simulator off.

6. PACER TESTS

NOTE: Section 6 tests are to be performed only on ZOLL 1600/1700 units, which are equipped with the optional Pacing function.

- Pacer Output Load Resistor, which consists of a 5 Watt or greater, 1KΩ resistor.
- Oscilloscope
- Frequency counter
- DYNATECH Impulse 4000 or equivalent.

Measurements are made with an oscilloscope probe connected to the positive (sternum) side of the resistor, and with the ground of the probe connected to the negative (apex) side. See diagram for determining polarity of Multi-Function Cable connector.

Multi-Function Cable Connector

6.1 ENTER DIAGNOSTICS MODE

To power up the ZOLL 1600/1700 device in extended diagnostics mode:

- Plug MFC into ZOLL 1600/1700.
- Press and hold the **SYNC** button for at least 7-10 seconds (until an additional beep is heard after the standard 4 power-up beeps) while turning the **SELECTOR SWITCH** to **POWER ON**.
- Battery voltage is displayed on CRT
- Mark the Checkout Procedure Data Sheet.

6.2 TEST PROCEDURE

- Turn to pacer on.
- Turn the Manual Key/Manual overide switch clockwise (to 3 o'clock position) and release.
- Turn the key/switch clockwise (to 3 o'clock position) again within 5 seconds to confirm **Manual Mode** Operation.
- Adjust **RATE** to 120 ppm.
- Connect the pacer output load resistor to the MFC cable.
- Set the scope as follows:
- 1 Volt per division.
- 0.2 or 0.5 Second per division.
- With the frequency counter and oscilloscope connected to the test load, turn the **OUTPUT** control to 0 mA.
- The display on the oscilloscope should show a high frequency square wave of approximately 1.4Vpp at 0 ma.

- Mark the Checkout Procedure Data Sheet.
- Watch the scope display while switching the **SELECTOR SWITCH** from **PACER ON** to **OFF**. Spikes or transients should be less than approximately 2.4V.
- Mark the Checkout Procedure Data Sheet.

6.3 TEST PROCEDURE

- Set the **OUTPUT** to 15 mA.
- Disconnect the pacer output load from the ZOLL 1600/1700 device.
- "PACER LEAD OFF" appears in the lower half of the display.
- Mark the Checkout Procedure Data Sheet.

6.4 TEST PROCEDURE

- Reconnect the pacer output load.
- The "PACER LEAD OFF" display is removed from the CRT display.
- Mark the Checkout Procedure Data Sheet.

6.5 TEST PROCEDURE

- Set the **RATE** to 180 ppm.
- Set the **OUTPUT mA** to 0 mA.
- Note the output current reading on the ZOLL 1600/1700 device and the actual wave amplitude on the scope.
- The digital display will match the **OUTPUT mA** setting
- Mark the Checkout Procedure Data Sheet.

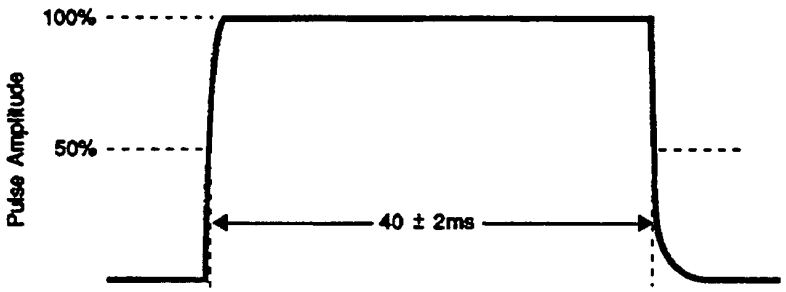
6.6 REPEAT PROCEDURE

- Repeat step 6.5 for each setting on the **OUTPUT mA** control (20, 40, 60, 80, 100, 120, 140, MAX).
- The pulse voltage shall be 1V per mA (i.e., 20 mA = 20 +/- 8V) for each set point. Adjust scope voltage setting as appropriate. (Set scope to DC coupling).
- Mark the Checkout Procedure Data Sheet.

6.7 TEST PROCEDURE

- Set **OUTPUT mA** to 60 mA.
- Measure the pulse period (frequency) and pulse width at the following RATE settings: MIN, 40, 60, 80, 100, 120, 180 and MAX (fully clockwise).
- Pulse period (display) shall be within +/- 8 ppm at each setting.
- The pulse width will be 40 ms +/- 2 ms at each setting.
- Measure the pulse width only where specified.
- Refer to **Figure 1**
- Mark the Checkout Procedure Data Sheet.

Figure 1



Voltage Waveform Measurement

(ppm) Dial Setting	Period Range (ms)	Pulse Width Tolerance
MIN	1579-2727	38-42 ms
40	1250-1875	"
60	882-1154	"
80	680-833	"
100	555-652	38-42ms
120	468 - 536	"
180	319- 349	"
MAX	319-349	38-42 ms

7. DEFIBRILLATOR TESTS

EQUIPMENT REQUIRED:

- Multi-Function Electrode Cable (MFC)
- MFC Test Adaptor Connector (Dynatech Nevada Part Number 3010-0378 or equivalent).
- Dynatech Nevada Impulse 3000, 4000 or equivalent defibrillator analyzer.
- ECG Cable
- Stopwatch
- Test Port Connector (1004-0053)

WARNING

- USE EXTREME CAUTION IN PERFORMING THE FOLLOWING TESTS!!!
- Keep hands and all other objects clear of Multi-Function Electrodes when discharging.
- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

7.1 TEST PROCEDURE (MANUAL MODE)

Unit should be off. The MFE cable and ECG cable should not be connected to the ZOLL 1600/1700 device.

- Turn the **SELECTOR SWITCH** to **POWER ON.**
- "CABLE FAULT" should be displayed on the CRT.
- Mark the Checkout Procedure Data Sheet.

7.2 TEST PROCEDURE (MANUAL MODE)

- Turn the Manual Key/switch clockwise (to 3 o'clock position) and release.
- Turn the key/switch clockwise (to 3 o'clock position) again within 5 seconds to confirm **Manual Mode** Operation.
- Connect the MFE Cable (MFC) to the ZOLL 1600/1700 device. Connect the MFC Test Adaptor Connector to the end of the MFE Cable.
- "CABLE FAULT" is replaced by "ELECTRODES"
- Select 100J using energy select buttons.
- Press the **CHARGE** button.
- Listen for the "STAND CLEAR" voice prompt.
- The charge time should be greater than 2 seconds and less than 10 seconds.
- Mark the Checkout Procedure Data Sheet.

7.3 TEST PROCEDURE (MANUAL MODE)

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit .
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- When ready tone is sounded.
- Press and HOLD the **SHOCK** button.

  The unit should discharge and the "100J RDY" message should be removed from the display.
- "TEST OK" should appear on CRT and stripchart recording.
- Mark the Checkout Procedure Data Sheet.
- Disconnect Defibrillator test port connector from Multi-Function Electrodes.

7.4 TEST PROCEDURE (MANUAL MODE)

- Place the Dynatech Impulse 3000, 4000 or equivalent defibrillator analyzer beside the ZOLL 1600/1700 device.
- Place the two electrodes from the MFC Test Adaptor on the appropriate discharge area of the defibrillator tester, or else wire the end of the MFE Cable to the defibrillator analyzer. Be sure to properly connect the APEX and STERNUM electrodes to the analyzer terminals.
- Connect the ZOLL 1600/1700 device's ECG patient cable to the Dynatech Impulse 3000, 4000 defibrillator analyzer (or equivalent) output terminal jacks, observing the correct color codes.
- Press the Cardio switch (or enter synchronized cardioversion timing test mode on other testers).
- Select ELECTRODES and **SIZE** 1x .
- Press the **SYNC** button.
- QRS complexes of 10 mm +/- 1 mm amplitude. Heart Rate = 60 bpm +/- 2.
- The Heart symbol on the CRT blinks on and off at 60 bpm.
- A sync marker on the monitor (a higher intensity line on the ECG R-wave peaks)
- "SYNC" is displayed on the monitor.
- Mark the Checkout Procedure Data Sheet.

7.5 TEST PROCEDURE (MANUAL MODE)

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit .
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Disconnect the ECG cable from the ZOLL 1600/1700 device.
- Set energy level to 360J using the front panel energy select button, Select Lead I.
- Press the **CHARGE** button on the front panel.
- With a new, fully charged battery, the charge time should be less than 10 seconds.
- Mark the Checkout Procedure Data Sheet.
- When the charge tone is sounded, press and HOLD the **SHOCK** button (for at least 5-10 seconds).
- The ZOLL 1600/1700 device will not discharge (because there is no ECG R wave to SYNC on).
- Mark the Checkout Procedure Data Sheet.
- Reconnect the ECG cable to the ZOLL 1600/1700 device.

7.6 TEST PROCEDURE (MANUAL MODE)

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit .
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Press and HOLD the **SHOCK** button.
- The defibrillator discharges.
- The ECG waveform should return to baseline within 4 seconds.
- The energy displayed on the defibrillator analyzer should be 306 - 414J.
- The delay time displayed on the defibrillator analyzer is 60 ms or less.
- Mark the Checkout Procedure Data Sheet
- Repeat discharging at all energy selections (Without Sync)
- (The limits are +/-15% or 4 Joules, whichever is greater).
- Mark the Checkout Procedure Data Sheet

7.7 TEST PROCEDURE (MANUAL MODE)

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit .
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Select "ELECTRODES" as lead.
- Set energy level to 360J.
- Press the **CHARGE** button. Then discharge the unit into the defibrillator tester.
- The ECG display should show a negative wave following the initial transient (only if the tester has playback capabilities).
- Mark the Checkout Procedure Data Sheet.

7.8 TEST PROCEDURE (MANUAL MODE)

- Set energy level to 360J.
- Erase any previous data stored in the summary report memory by pressing the **SUMMARY** button and the **SET UP ARROW (▲)** button simultaneously for 4-8 seconds until "ERASING REPORT" appears on the CRT.
- Mark the Checkout Procedure Data Sheet.

7.9 TEST PROCEDURE (MANUAL MODE)

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit .
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Press the **CHARGE** button. Then discharge into a defibrillator tester.
- Verify that unit successfully discharges.
- Mark the Checkout Procedure Data Sheet.

7.10 TEST PROCEDURE (MANUAL MODE)

- Turn the unit off, wait 5 seconds, and then turn to **POWER ON**.
  (**NOTE:** If the unit is turned off for more than 10 seconds it will power up in Semi Automatic Mode).
- Press the **SUMMARY** button. The recorder should output a summary report with the correct date and time and a TOTAL SHOCKS of 1 (if the unit is equipped with a recorder)
- It should also output a defibrillator event printout with a joules selection of 360.
- Mark the Checkout Procedure Data Sheet.

7.11 TEST PROCEDURE (MANUAL MODE)

- Turn the **SELECTOR SWITCH** to **POWER ON**.
- Turn the Manual Key/switch clockwise (to 3 o'clock position) and release.
- Turn the key/switch clockwise (to 3 o'clock position) again within 5 seconds to confirm **Manual Mode** Operation.
- Using the energy level select buttons, select 300J.
- Press the **CHARGE** button on the front panel, to charge the unit.
- Using the energy level select buttons, select 360J.
- Observe that the unit discharges internally
- Using the energy level down select button (▼) press and observe energy level decrements each time to the next level.
- Turn on the recorder using the **RECORDER ON-OFF** button. Verify correct time and date on recorder annotation. Turn off recorder.
- Mark the Checkout Procedure Data Sheet.

7.12 TEST PROCEDURE (MANUAL MODE)

- Turn the **SELECTOR SWITCH** to **POWER ON**.
- Turn the Manual Key clockwise (to 3 o'clock position) and release.
- Turn the key clockwise (to 3 o'clock position) again within 5 seconds to confirm **Manual Mode** Operation.
- Set the energy level to 2J.
- With the MFC installed and plugged into the test port connector, press **CHARGE** to charge the ZOLL 1600/1700 device to 2J.
- Remove the test port connector (ZOLL part number 1004-0053 designed for the 1400-Series products).
- Verify that the messages "CHK ELECTRODES" & "2J SEL" appear on the display.
- Mark the Checkout Procedure Data Sheet.

7.13 TEST PROCEDURE (MANUAL MODE)

Plug the MFC into the test port connector (ZOLL part number 1004-0053 designed for the 1400-Series products).

- If the unit is not still charged, check that 2J is selected, and press **CHARGE** to charge it to 2J.
- Discharge into the test port connector.
- Verify that the unit successfully discharges into the load by checking that the screen message changes back to "2J SEL".
- Mark the Checkout Procedure Data Sheet.

8. SEMI-AUTOMATIC MODE TESTS

This section does not apply to MANUAL ONLY devices.

8.1 TEST SETUP

Unit should be off for at least 10 seconds.

- ECG cable not connected to unit.
- Install the Multi-Function Cable (MFC) with no load.
- Turn the unit to **POWER ON, "CHK ELECTRODES"** message appears on the screen.
- Make sure there is paper installed in the paper well. (if equipped with a recorder)

WARNING

- **HIGH VOLTAGE!**
- Keep the cable end away from human and/or metal contact.
- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

8.2 TEST PROCEDURE

- Verify that neither "CHARGE" nor "ANALYZE" appear on the display.
- With the MFC installed and not plugged into the test port connector, press the **Gray** button on the defibrillator main control panel.
- Verify that the unit **does not Charge** and **does not Analyze** and a dashed ECG Base Line appears (if option is ON).
- No indication of charging or analyzing on the CRT.
- Mark the Checkout Procedure Data Sheet.

8.3 TEST PROCEDURE

- Plug the MFC into Impulse 3000, 4000 or ZOLL S-3000 simulator.

NOTE: ECG simulator must have a circuit impedance less than 250 Ω.

- Press the **ANALYZE** button for each of the rhythms in the table below.
- Listen for the "STAND CLEAR" voice prompt. Check that the accompanying message is displayed for each rhythm.

RHYTHM	MESSAGE
Normal Sinus	**NO SHOCK ADVISED**
Ventricular Fibrillation	**SHOCK ADVISED**
Asystole	**NO SHOCK ADVISED**
Ventricular Tachycardia > 150	**SHOCK ADVISED**
Ventricular Tachycardia < 150	**NO SHOCK ADVISED**

9. REAL TIME CLOCK CHECK

9.1 TEST PROCEDURE

- Press the **RECORDER ON-OFF** button (If equipped with recorder option) to get a print-out on the recorder paper of the date and time.
- Verify that the date and time are still correct.

10. MRM TESTS

10.1 TEST SETUP

- Plug the MFC into Impulse 3000/4000 or ZOLL S-3000 simulator.
- Set the simulator to produce a recognizable cardiac rhythm.

10.2 TEST PROCEDURE

SEMI-AUTOMATIC DEVICES

- Turn the **SELECTOR SWITCH** to **POWER ON.**
- Disconnect the MFC from the simulator.
- Listen for "CHECK ELECTRODES" voice prompt.
- Press the **VOLUME DOWN** (▼) arrow button at least three times.
- Reconnect the simulator. After a few seconds, disconnect the simulator.
- Listen for the reduced volume of the "CHECK ELECTRODES" voice prompt.
- Press the **VOLUME UP** (▲) arrow button at least five times.
- Reconnect the simulator. After a few seconds, disconnect the simulator.
- Listen for the increased volume of the "CHECK ELECTRODES" voice prompt.
- Turn the **ZOLL** 1600/1700 unit **OFF.**

MANUAL ONLY DEVICES

- Turn the **SELECTOR SWITCH** to **POWER ON.**
- Disconnect the MFC from the simulator.
- Look for "CHK ELECTRODES" on the display.
- Turn the **ZOLL** 1600/1700 unit **OFF.**

10.3 TEST PROCEDURE (OPTIONAL)

This test can be only be performed with ZOLL Data Control Software and a properly configured PC.

- Plug the MFC into Dynatech Impulse 3000/4000 or ZOLL S-3000 simulator.
- Set the simulator to produce a recognizable cardiac rhythm.
- Install an empty Memory Card into the Memory Card slot.
- Turn **SELECTOR SWITCH** to **POWER ON.**

- Speak while pressing the **F1-F4** event marker buttons on the MRM. Say which button you are pressing, in order to later identify the correct event during playback.

NOTE: ZOLL 1600/1700 units without the voice recording option record only the ECG and event annotation data.

- Remove the Memory Card
- Turn the ZOLL 1600/1700 unit **OFF**.
- Transfer the data from the Memory Card to the ZOLL Data Control system according to the ZOLL 1600/1700 Operators Manual.
- Verify via ZOLL Data Control system that ECG signal is recognizable and event annotation 1-4 are properly recorded. If voice recording option is installed, note that voice is clear and intelligible.

ZOLL 1600/1700 DEVICE CHECKOUT PROCEDURE

DATA SHEET

S/N _____ **OPERATOR** _____ **DATE** _____

COPY THIS FORM BEFORE USING ! !

SECTION 1. INITIALIZE TEST

Perform this Action:	Look for:	Circle the Result
1.1 ***Semi-automatic devices***		
*Turn the **SELECTOR SWITCH** to **POWER ON.***	4 Beep Audible Tone heard.	**YES NO**
	"CHECK MEMORY CARD" voice prompt sounds.	**YES NO**
Manual Only devices		
*Turn the **SELECTOR SWITCH** to **POWER ON.***	Several tones heard.	**YES NO**
	"INSERT CARD" on display.	**YES NO**
1.2 (If equipped with a recorder).		
Remove paper from recorder.		
*Press **RECORDER ON-OFF** button.*	"NO PAPER" message appears.	**YES NO**
Put paper into the recorder		
*Press **RECORDER ON-OFF** button.*	"NO PAPER" message is removed.	**YES NO**
1.3 *Change date and time (if necessary).*	Displays correct date and time.	**YES NO**
1.4 *Press **RECORDER ON-OFF** button.*	Correct date and time is printed on recorder paper.	**YES NO**

SECTION 2. LEAKAGE TESTS

Perform this Action:		Look for GND Normal GND Open:	Circle the Result
2.2 ECG	Normal	_____ - _____ < 10µA	YES NO
	Reversed	_____ - _____ < 10µA	YES NO
Risk Current (with patient ECG cable)		_____ - _____ < 20µA	YES NO
MFC	Normal	_____ - _____ < 100µA	YES NO
	Reversed	_____ - _____ < 100µA	YES NO
MFC Risk Current		_____ - _____ < 100µA	YES NO

SECTION 3. DIAGNOSTICS MODE TESTS

NOTE: Section 3 tests are to be performed only on ZOLL 1600/1700 units, which are equipped with the optional Pacing function.

Perform this Action:	Look for:		Circle the Result
3.1 *Power up the unit in diagnostics mode.*	5 Beeps heard.		YES NO
	Battery voltage displayed.		YES NO
3.2 *Turn unit to **PACER ON**.* Turn the Manual Key /switch clockwise (to 3 o'clock position) and release. Turn the key/switch clockwise (to 3 o'clock position) again within 5 seconds to confirm Manual Mode Operation. Set RATE to 30, 80, 180ppm	Pace rate displays	30+/- 8 80+/- 8 180+/- 8	YES NO YES NO YES NO
3.3 *Set **OUTPUT** to 20, 80, 140 mA.*	Pace output display	20+/- 8 80+/- 8 140+/- 8	YES NO YES NO YES NO

SECTION 4. POWER SUPPLY TESTS (OPTIONAL)

Perform this Action:		Look for:	Circle the Result
4.2	*Power supply set at 7V.*	Unit remains off.	**YES NO**
	Power supply set at 9.3V.	Unit turns on.	**YES NO**
4.3	*Power supply set at 9.3V.*	"LOW BATTERY" message displayed within 30 seconds.	**YES NO**
	Power supply set at 8.75V.	Unit shuts off within 30 seconds.	**YES NO**
4.5	*Measure voltage across 0.1Ω resistor.*	Voltage less than 120 mV.	**YES NO**
4.7	*Measure voltage across 1KΩ resistor.*	Voltage less than 170 mV.	**YES NO**

SECTION 5. ECG TESTS

Perform this Action:		Look for:	Circle the Result
5.1	*Power up unit in lead I. Connect simulator to unit and set simulator to 120 bpm, 1 mV amplitude. Repeat for Leads II & III*	Heart Rate display is 120 +/- 2 bpm.	**YES NO**
5.2	*Disconnect each lead and check for "LEAD OFF".*	"LEAD OFF" message displayed for each lead.	**YES NO**
	Repeat for lead select setting II	"LEAD OFF" message displayed for each lead.	**YES NO**
	Repeat for lead select setting III	"LEAD OFF" message displayed for each lead.	**YES NO**
5.3	*Check volume control adjustment.*	QRS Volume OFF.	**YES NO**
		QRS Volume ON.	**YES NO**
5.4	*Select lead I and step through size select.*	Lead I Size Select .5x,	**YES NO**
		1x,	**YES NO**
		1.5x	**YES NO**
		2x	**YES NO**
		3x	**YES NO**
5.5	*Connect scope probe to ECG OUT jack.*	ECG out is 1+/- 0.2V.	**YES NO**

SECTION 5. ECG TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
5.6 *Generate cal pulses on strip chart*	Cal pulse (10 mm +/- 1 mm).	**YES NO**
5.7 *Select lead I, size 3x. Set simulator to output 1 mV 60Hz (or 50Hz if it is a 50Hz unit).*	Recorder wave form <1.5 mm.	**YES NO**

SECTION 6. PACER TESTS

NOTE: Section 6 tests are to be performed only on ZOLL 1600/1700 units, which are equipped with the optional Pacing function.

Perform this Action:	Look for:	Circle the Result
6.1 *Put unit into diagnostics mode.*	5 Beeps heard. (6 beeps in Manual) Battery voltage displayed.	**YES NO** **YES NO**
6.2 *Set unit to **PACER ON**,* Turn the Manual Key / switch clockwise (to 3 o'clock position) and release. Turn the key clockwise (to 3 o'clock position) again within 5 seconds to confirm Manual Mode Operation. *Set 120 ppm, 0 mA output. Connect pace output load cable, frequency counter, and scope.* *Turn off unit and turn back on checking for transients*	Scope shows approximately 1.4Vpp at 0 mA. Scope shows Spikes/ transients < approximately 2.4V.	**YES NO** **YES NO**
6.3 *Turn **OUTPUT** to 15 mA. Disconnect pacer cable.*	"PACER LEAD OFF" message displayed on CRT.	**YES NO**
6.4 *Reconnect pacer cable.*	"PACER LEAD OFF" message is removed.	**YES NO**
6.5 *Set **OUTPUT** to 0 mA..*	Pulse voltage is 0V.	**YES NO**

SECTION 6. PACER TESTS (CONTINUED)

Perform this Action:	Look for:		Circle the Result
6.6 *Set **OUTPUT knob** to*			
20 mA	Pulse voltage is 20V +/- 8V.		**YES NO**
40 mA	Pulse voltage is 40V +/- 8V.		**YES NO**
60 mA	Pulse voltage is 60V +/- 8V.		**YES NO**
80 mA	Pulse voltage is 80V +/- 8V.		**YES NO**
100 mA	Pulse voltage is 100V +/- 8V.		**YES NO**
120 mA	Pulse voltage is 120V +/- 8V.		**YES NO**
140 mA	Pulse voltage is 140V +/- 8V.		**YES NO**
6.7 *Measure pulse period and width with **RATE** set to:*	Pulse period is:	Pulse width is:	
MIN	1579-2727	38-42 ms	**YES NO**
40	1250-1875	38-42 ms	**YES NO**
60	882-1154	38-42 ms	**YES NO**
80	680-833	38-42 ms	**YES NO**
100	555-652	38-42 ms	**YES NO**
120	468-536	38-42 ms	**YES NO**
180	319-349	38-42 ms	**YES NO**
MAX	319-349	38-42 ms	**YES NO**

SECTION 7. DEFIBRILLATOR TESTS

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the ZOLL 1600/1700 device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

Perform this Action:	Look for:	Circle the Result
7.1 *Disconnect MFE cable. Set **SELECTOR SWITCH** to **POWER ON**.* *Turn manual key/switch* (clockwise to 3 o'clock) *twice to enter Manual mode.*	"CABLE FAULT" message is displayed on CRT.	**YES NO**
7.2 *Connect MFC.* *Set energy level to 100J. Press **CHARGE** button.*	"CABLE FAULT" message replaced by "ELECTRODES". Charge time greater than 2 seconds and less than 10 sec. "STAND CLEAR" voice prompt.	**YES NO** **YES NO** **YES NO**
7.3 *Press and HOLD **SHOCK** button.*	Unit discharges. "100J RDY" message disappears. "TEST OK" message appears. "TEST OK" prints on strip chart.	**YES NO** **YES NO** **YES NO** **YES NO**

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
7.4 *Place MFEs in the Defib tester. Select "ELECTRODES" as lead. Set energy level to 360J, **SIZE** = 1x. Press the **SYNC** button.*	QRS complexes of 10 mm +/- 1 mm amplitude.	**YES NO**
	Heart Rate = 60 BPM +/- 2.	**YES NO**
	Heart symbol on the CRT blinks on and off.	**YES NO**
	"SYNC" marker on waveform.	**YES NO**
7.5 *Disconnect ECG cable. Set lead I and energy level to 360J. Press **CHARGE** button and time charge.*	Charge time with new, fully charged battery < 10 seconds."360J RDY" message displayed	**YES NO**
*Press & HOLD **SHOCK** button.*	"SYNC" 360J RDY" message displayed unit does not discharge.	**YES NO**
Reconnect ECG cable.		
7.6 *Press & HOLD **SHOCK** button.*	"360J RDY" message disappears. Unit discharges.	**YES NO**
	Baseline return in <= 4 sec.	**YES NO**
	Energy delivered to defib tester 306 - 414J.	**YES NO**
	Delay time displayed on Defib analyzer < 60 ms.	**YES NO**

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
7.6 *Set energy level to* 2J *Press* ***CHARGE*** *button.*	"2J RDY" message displayed.	**YES NO**
Press and HOLD ***SHOCK*** *button.*	"2J RDY" message disappears. Unit discharges.	**YES NO**
	Baseline return in <= 4 sec.	**YES NO**
	Energy delivered to defib tester 1 - 6J.	**YES NO**
Set energy level to 3J. *Press* ***CHARGE*** *button.*	"3J RDY" message displayed.	**YES NO**
Press and HOLD ***SHOCK*** *button.*	"3J RDY" message disappears. Unit discharges.	**YES NO**
	Baseline return in <= 4 sec.	**YES NO**
	Energy delivered to defib tester 1 - 7J.	**YES NO**
Set energy level to 5J. *Press* ***CHARGE*** *button.*	"5J RDY" message displayed.	**YES NO**
Press and HOLD ***SHOCK*** *button.*	"5J RDY" message disappears. Unit discharges.	**YES NO**
	Baseline return in <= 4 sec.	**YES NO**
	Energy delivered to defib tester 1 - 9J.	**YES NO**

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:		Look for:	Circle the Result
7.6	*Set energy level to* 7J *Press* ***CHARGE*** *button.*	"7J RDY" message displayed.	**YES NO**
	Press and HOLD ***SHOCK*** *button.*	"7J RDY" message disappears. Unit discharges.	**YES NO**
		Baseline return in <= 4 sec.	**YES NO**
		Energy delivered to defib tester 3 - 11J.	**YES NO**
	Set energy level to 10J *Press* ***CHARGE*** *button.*	"10J RDY" message displayed.	**YES NO**
	Press and HOLD ***SHOCK*** *button.*	"10J RDY" message disappears. Unit discharges.	**YES NO**
		Baseline return in <= 4 sec.	**YES NO**
		Energy delivered to defib tester 6 - 14J.	**YES NO**
	Set energy level to 20J *Press* ***CHARGE*** *button.*	"20J RDY" message displayed.	**YES NO**
	Press and HOLD ***SHOCK*** *button.*	"20J RDY" message disappears. Unit discharges.	**YES NO**
		Baseline return in <= 4 sec.	**YES NO**
		Energy delivered to defib tester 16 - 24J.	**YES NO**

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
7.6 *Set energy level to* 30J *Press* ***CHARGE*** *button.*	"30J RDY" message displayed.	**YES NO**
Press and HOLD ***SHOCK*** *button.*	"30J RDY" message disappears. Unit discharges.	**YES NO**
	Baseline return in <= 4 sec.	**YES NO**
	Energy delivered to defib tester 25.5 - 34.5J.	**YES NO**
Set energy level to 50J Press ***CHARGE*** *button.*	"50J RDY" message displayed.	**YES NO**
Press and HOLD ***SHOCK*** *button.*	"50J RDY" message disappears. Unit discharges.	**YES NO**
	Baseline return in <= 4 sec.	**YES NO**
	Energy delivered to defib tester 42.5 - 57.5J.	**YES NO**
Set energy level to 100J *Press* ***CHARGE*** *button and time charge.*	"100J RDY" message displayed.	**YES NO**
Press and HOLD ***SHOCK*** *button.*	"100J RDY" message disappears. Unit discharges.	**YES NO**
	Baseline return in <= 4 sec.	**YES NO**
	Energy delivered to defib tester 85 - 115J.	**YES NO**

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:		Look for:	Circle the Result
7.6	*Set energy level to* 150J *Press* ***CHARGE*** *button*	"150J RDY" message displayed.	**YES NO**
	Press and HOLD ***SHOCK*** *button.*	"150J RDY" message disappears. Unit discharges.	**YES NO**
		Baseline return in <= 4 sec.	**YES NO**
		Energy delivered to defib tester 127.5 - 172.5J.	**YES NO**
	Set energy level to 200J *Press* ***CHARGE*** *button.*	"200J RDY" message displayed.	**YES NO**
	Press and HOLD ***SHOCK*** *button.*	"200J RDY" message disappears. Unit discharges.	**YES NO**
		Baseline return in <= 4 sec.	**YES NO**
		Energy delivered to defib tester 170 - 230J.	**YES NO**
	Set energy level to 300J *Press* ***CHARGE*** *button*	"300J RDY" message displayed.	**YES NO**
	Press and HOLD ***SHOCK*** *button.*	"300J RDY" message disappears. Unit discharges.	**YES NO**
		Baseline return in <= 4 sec.	**YES NO**
		Energy delivered to defib tester 255 - 345J.	**YES NO**

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
7.7 *Select ELECTRODES as leads. Set to 360J. Press the **CHARGE** button. Discharge the unit into the defibrillator tester.*	The ECG display shows a negative-going wave following the initial transient (if tester has "playback" capability).	**YES NO**
7.8 *Set energy to 360J.Press **SUMMARY** button and **SET UP (▲) ARROW** simultaneously for 4 sec. until "ERASING REPORT" appears on CRT.*	"ERASING REPORT" message appears on CRT.	**YES NO**
7.9 *Press **CHARGE** button. Discharge into defibrillator tester.*	Unit discharges.	**YES NO**
7.10 *Turn unit off, wait for at least five (5) seconds and no more than 10 seconds. Then turn unit on. Press **SUMMARY** button.*	Recorder output summary report with time and date and TOTAL SHOCKS = 1. Event Printout Joules Selected 360.	**YES NO** **YES NO**
7.11 *Select 300J with energy select button.* *Press **CHARGE** button on front panel.* *Select 360J with energy select button.* *Press energy down (▼) for each level* *Turn on recorder with **RECORDER ON-OFF** button.(if so equipped)*	 Unit discharges internally. Unit decrements selected value Correct time and date displayed.	 **YES NO** **YES NO** **YES NO**
7.12 Set the energy level to 2J and charge. Remove test port connector.	"CHK ELECTRODES" & "2J SEL" message appears on CRT.	**YES NO**
7.13 Plug MFC into test connector, charge to 2J and discharge.	Unit discharges and "2J SEL" message reappears.	**YES NO**

SECTION 8. SEMI-AUTOMATIC MODE TESTS

NOTE: This section does not apply to Manual Only devices.

Perform this Action:	Look for:	Circle the Result
8.1 *Multi-Function Cable not Connected to Test Load.*	"CHK ELECTRODES" message appears on display.	**YES NO**
8.2 *Press **CHARGE/ ANALYZE** Button*	No CHARGE or ANALYZE on CRT display	**YES NO**
	No indication of charging on CRT.	**YES NO**

SECTION 8. SEMI-AUTOMATIC MODE TESTS (CONTINUED)

8.3	*Connect MFC to Simulator.*		**YES NO**
	Set Simulator to a Normal Sinus rhythm.		**YES NO**
	*Press **ANALYZE** button.*	STAND CLEAR voice prompt.	**YES NO**
		"NO SHOCK ADVISED" message appears on CRT.	**YES NO**
	Set Simulator to a Ventricular Fibrillation rhythm.		**YES NO**
	*Press **ANALYZE** button*	STAND CLEAR voice prompt.	**YES NO**
		"SHOCK ADVISED" message appears on CRT.	**YES NO**
		"PRESS SHOCK" message appears on CRT.	**YES NO**
	*Press and hold **SHOCK** button to discharge energy into Simulator.*		**YES NO**
	Set Simulator to a Asystole rhythm.		**YES NO**
	*Press **ANALYZE** button.*	STAND CLEAR voice prompt.	**YES NO**
		"NO SHOCK ADVISED" message appears on CRT.	**YES NO**
	Set Simulator to a Ventricular Tachycardia > 150.		**YES NO**
	*Press **ANALYZE** button.*	STAND CLEAR voice prompt.	**YES NO**
		"SHOCK ADVISED" message appears on CRT.	**YES NO**
	*Press and hold **SHOCK** button to discharge energy into Simulator.*	"PRESS SHOCK" message appears on CRT.	**YES NO**
	Set Simulator to a Ventricular Tachycardia < 150		**YES NO**
	*Press **ANALYZE** button.*	STAND CLEAR voice prompt.	**YES NO**
		"NO SHOCK ADVISED" message appears on CRT.	**YES NO**

SECTION 9. REAL TIME CLOCK TEST

Perform this Action:	Look for:	Circle the Result
9.1 Press Recorder ON/OFF button	Correct date and time printed on the strip chart recorder paper.	**YES NO**

SECTION 10. MRM TESTS

Perform this Action:	Look for:	Circle the Result
10.2 Semi-automatic devices		
Disconnect the simulator.	"CHECK ELECTRODES" voice prompt.	**YES NO**
Press VOLUME Down (▼) arrow button repeatedly.	"CHECK ELECTRODES" voice prompt at low volume.	**YES NO**
Press VOLUME Up (▲) arrow button repeatedly.	"CHECK ELECTRODES" voice prompt at high volume.	**YES NO**
Manual Only devices		
Disconnect the simulator.	"CHK ELECTRODES" on display.	**YES NO**
10.3 Record ECG, Event Annotation, and Voice Data onto Memory card.	ECG recognizable.	**YES NO**
Play back Memory Card	Event Annotation 1-4.	**YES NO**
	Voice recording clear and intelligible. (Units with voice recording option only).	**YES NO**

SECTION III
TROUBLESHOOTING AIDS

The operational troubleshooting guide can be found in the Operator's Manual (Appendix A) This section answers many of the common problems or questions that arise during operation.

If trouble persists after consulting this guide, contact the appropriate technical personnel or ZOLL Technical Service Department.

Text Messages III-2

Status Messages III-4

ZOLL 1600-SERIES TEXT MESSAGES

Message Text	Message Description
PACE/DEFIB FLT	Pace / Defib Board Revision is invalid.
SET CLOCK	Current Time Invalid.
REPORT FAULT	Error while storing Configuration or Summary Report Data.
REPORT FULL	Summary Report Memory is Full.
ERASING REPORT	Summary Report is being erased.
USER SETUP REQ	Configuration Data not Valid.
LOW BATTERY	Battery Voltage is Low.
PACER LEAD OFF	Pacing Leads are not connected to patient.
CHK. ELECTRODES	Multi Function Electrodes (MFE's) are not properly attached to patient.
CABLE FAULT	Multi Function Cable (MFC) not connected to PD 1600.
NO PAPER	Strip Chart Paper Empty.
ECG LEAD OFF	ECG leads are not connected to patient.
NOISY ECG	The ECG signal is too noisy to properly determine rhythm characteristics.
RETRY ANALYSIS	Instructs the user to start ECG Analysis again when analysis has been stopped due to noisy ECG signal.
CHECK PATIENT	Continuous analysis has detected a shockable rhythm.
PRESS ANALYZE	Displayed instead of CHECK PATIENT in auto-defib mode if this configuration option is selected.
ANALYSIS HALTED	Analysis halted due to defibrillator fault.
BUTTON ERROR	Too many buttons pressed simultaneously.

ZOLL 1600-SERIES TEXT MESSAGES (CONTINUED)

Message Text	Message Description
VF ALARMS OFF	Continuous analysis will not be performed when Heart Rate Alarms are enabled.
SHORTED DISCH	Too high an energy (>200J) delivered into internal defib self-testing shorting bar.
REPLACE CARD	Memory card error has been detected requiring a new card to be inserted (wrong card type, defective card, etc.)
CARD NOT EMPTY	A card is inserted at startup or during operation that is not entirely empty.
INSERT CARD	Memory card is not installed or not seated properly in the unit. (Also displayed in config mode).
CARD FULL	Memory card is full.
CANNOT CHARGE	Cannot charge defibrillator.
CANNOT DUMP	Energy level on defib capacitor too high after safety (dump) relay is closed. DEFIB Capacitor voltage above target and still charging while not in charge mode.
RELEASE SHOCK	Instructs the user to release the shock button if they are pressing it before the "Press Shock" prompt is displayed.
PACE FAULT	Pace pulse amplitude error detected
TEST OK	Defib Test Passed
TEST FAIL	Defib Test Failed
CANNOT CHARGE	XSAFE = 0 and **CHARGE** button is pressed while STATUS 66 is being displayed.
PACE FAULT	VMON is rising in Pace Mode

ZOLL 1600-SERIES STATUS MESSAGES

Error Number	Description	Type of Problem
STATUS 3	CPU ROM checksum test failure	Self-Test
STATUS 5	EPU ROM error (displayed in diagnostic mode only)	Self-Test
STATUS 7	CPU does not receive any messages from the MRM for four (4) seconds	Comm Module
STATUS 11	Real-Time Clock error - restart RTC.	RTC Module
STATUS 15	EPROM programming voltage low	NV Memory Module
STATUS 18	Strip Chart recorder failure or program logic problem.	Summary Report Module
STATUS 19	First Summary Report record invalid - should erase automatically and reset	Summary Report Module
STATUS 26	CRT VRAM error	CRT Self-Test
STATUS 32	EPU unable to generate display text	EPU Display Module
STATUS 41	Manual Key A/D reading exceeds legal limits	CPU A/D Module
STATUS 42	CPU 2.5 Reference Voltage is out of range.	CPU A/D Module
STATUS 43	CPU failed to shutdown via XPWR_KILL.	CPU Battery Monitor Module
STATUS 48	CPU ECG OUT D/A failure	Self-Test
STATUS 49	CPU A/D failure	Self-Test
STATUS 50	CPU VCTL D/A failure	Self-Test
STATUS 51	2.5V reference failure	Self-Test
STATUS 52	EPU A/D unable to complete conversion within specified time	EPU A/D Module
STATUS 56	No communications received from CPU for four (4) seconds.	Comm Module
STATUS 61	Transmit buffer full on EPU (diagnostic mode)	EPU Error Handling Module

ZOLL 1600-SERIES STATUS MESSAGES (CONTINUED)

Error Number	Description	Type of Problem
STATUS 66	EPU did not return the correct value for XSAFE to the CPU seven (7) times in a row (if **CHARGE** button pressed, "CANNOT CHARGE" also is displayed).	Defib Module
STATUS 81	Pace Amplitude pot pulled to ground or +5V.	A2D Module
STATUS 82	Pace Rate pot pulled to ground or +5V.	A2D Module
STATUS 88	CPU DEFIB - Capacitor Voltage is too high to discharge.	Defib Module
STATUS 89	CPU DEFIB - Capacitor Voltage is greater than the absolute rated maximum.	Defib Module
STATUS 90	CPU DEFIB - Unable to charge defibrillator capacitor.	Defib Module
STATUS 91	CPU DEFIB - Maximum allowable time has been exceeded without reaching target energy.	Defib Module
STATUS 93	This indicates that the PD board shut down due to a persistant defibrillator fault.	PD Board
STATUS 94	Undefined PADMON state.	PADMON A/D
STATUS 97	"Upper" discharge transistor (Q12) shorted or malfunctioned.	Self-Test
STATUS 98	"Lower" discharge transistor (Q102) shorted or malfunctioned.	Self-Test
STATUS 103	Discharge Switch Open Circuit.	Self-Test
STATUS 104	CPU and EPU target energies did not agree during defib charge.	EPU Monitor Module
STATUS 105	Defib capacitor voltage is rising and is more than 14% above selected energy when defib is charging and ready.	EPU Monitor Module
STATUS 107	Defib cap has reached its absolute maximum voltage as detected by the EPU.	EPU Monitor Module
STATUS 110	Pulse width greater than 16 ms as measured by EPU during defib impedance test,	EPU Monitor Module

ZOLL 1600-SERIES STATUS MESSAGES (CONTINUED)

Error Number	Description	Type of Problem
STATUS 123	During pace pulse, pulse width measured by the EPU is < 30 ms or > 50 ms. (diagnostic mode only).	EPU Monitor Module
STATUS 124	EPU VSNS sample or average sample is out of set limits. (diagnostic mode only).	EPU Monitor Module
STATUS 125	During pace pulse, pulse period as measured by EPU is < selected period minus 40 ms. (diagnostic mode only).	EPU Monitor Module
STATUS 126	No pace current measured by EPU within 40 ms of pace pulse marker. (diagnostic mode only).	EPU Monitor Module
STATUS 127	CPU is in pace mode but XPACE_SEL signal to the EPU indicates that the **SELECTOR SWITCH** is not in pace mode.	EPU Monitor Module
STATUS 138	Excessive change in defib cap energy as measured by CPU. Not a real error- diagnostic purposes in diagnostic mode only	Defib Module
STATUS 140	CPU DEFIB - XSAFE Request was not echoed back by the EPU.	CPU Defib Module
STATUS 142	An arithmetic overflow was detected during an IPEAK test.	CPU IPEAK Module
STATUS 143	An IPEAK test was run with 100J on the rotary setting and no energy was detected.	CPU IPEAK Module
STATUS 150	The CRT gate array program has overflowed its allotted storage.	EPU Display Manager
STATUS 156	Callers of the get trace samples are not keeping up with the ECG data stream.	EPU ECG Manager
STATUS 160	CPU Stripchart Reset failed.	Stripchart
STATUS 161	CPU Stripchart Echo Test failed.	Stripchart
STATUS 162	Stripchart took too long to respond to command (diagnostic mode only).	Stripchart
STATUS 163	ECG data buffer underflow (diagnostic mode only).	Stripchart
STATUS 164	ECG data buffer overflow (diagnostic mode only).	Stripchart
STATUS 165	CPU Strip Chart Over temperature Error.	Stripchart
STATUS 166	CPU Strip Chart Voltage is too high.	Stripchart

ZOLL 1600-SERIES STATUS MESSAGES (CONTINUED)

Error Number	Description	Type of Problem
STATUS 174	Communications transmit buffer full.	MRM
STATUS 177	Executive context switch error.	MRM
STATUS 180	Voice synthesizer HW fails to return to READY state.	MRM
STATUS 181	Audio Processor HW fails to respond to commands.	MRM
STATUS 182	MRM detects an illegal system mode.	MRM
STATUS 183	Illegal status value or ID	MRM
STATUS 184	IRM parameter block list is full	MRM
STATUS 185	IRM data queue is full	MRM
STATUS 186	IRM detects unknown data type	MRM
STATUS 187	MRM voice prompt request queue is full	MRM
STATUS 189	MRM detects a checksum error with a data packet from the voice synthesizer.	MRM
STATUS 190	MRM detects a NAK from the voice synthesizer	MRM
STATUS 191	MRM detects timeout condition by the voice synthesizer.	MRM

SECTION IV
FUNCTIONAL DESCRIPTIONS

This section describes the basic operation of the circuits and supplements the troubleshooting guides in Section III of this manual.

For additional information, refer to the associated schematics found in Section V.

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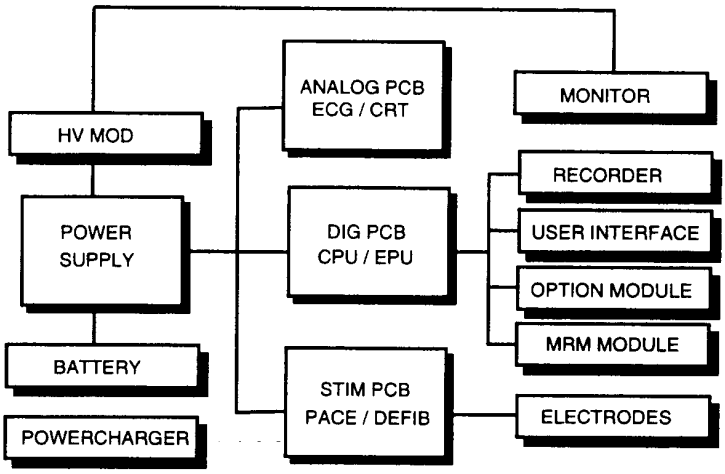
1. SYSTEM

The ZOLL 1600 has a modular design philosophy. Each of the major circuits is contained on a separate assembly, which if defective, can be directly exchanged with a factory calibrated replacement.



System Diagram

The seven major circuit assemblies and their functions are:

1. **Power Supply**

   The Power Supply assembly provides the system with all voltages required. The battery current is provided by way of a fuse to this circuit.

2. **Digital Board**

   The Digital Board assembly handles the primary instrument functions and enables interaction between the operator and the overall system. The circuit is designed around two microprocessors. The function of the CPU includes user interface, mode control, recorder, pacer pulse generation, defibrillation charge and discharge control, and code summary. The function of the EPU (ECG processing unit) includes ECG signal processing, CRT, and safety monitoring.

3. **Stimulator Board**

   The Stimulator Board assembly includes the Pacer and Defibrillator.

   The Defibrillator circuit will charge the high voltage capacitor (HVC) to the desired target energy and deliver the waveform shaped HVC energy to the patient connector. The high voltage capacitor circuit controls the shape and delivery of the energy waveform to the electrodes.

   The Pacer circuit provides patient isolated pacing pulses. Pulse rate and amplitude are controlled by the CPU in accordance with settings made by the front panel knobs.

4. **Analog Board**

   The Analog Board assembly includes the ECG amplifier and the CRT deflection circuits.

The ECG circuit receives ECG information from either the three lead input or the Defibrillator patient connector. The ECG signal is then amplified and filtered for display and EPU signal processing for QRS detection.

The CRT deflection circuit controls the presentation of ECG data and character information on the CRT.

5. **Medical Report Module**

The Medical Reporting Module saves ECG, event annotation, and optionally, ambient audio recording data to a PCMCIA card for later retrieval or RS-232 download, provides voice prompts, and provides a keyswitch which allows the unit to operate in manual mode.

6. **Recorder (Optional)**

The Recorder assembly prints ECG data and character information on the strip chart.

7. **High Voltage Module (HV Mod)**

The High Voltage Module provides all the high voltages necessary for CRT operation.

2. POWER SUPPLY

The Power Supply circuit converts the battery voltage (RAWBATT) into the supply voltages shown in the table. In addition, RAWBATT is passed through a relay to provide separate switched battery voltages SWBATT for the unit and AUX_PWR (via a second "fuse") for option modules. The Power Supply provides power and signal distribution to the Analog board (P5), Digital board (P7), Yoke (P4), CRT (P3), Option Module (P2), and High Voltage Multiplier (P1).

The voltages referred to below assume that a fully charged battery is in place. However, the Power Supply is capable of operating over a battery voltage range of 8-12 volts.

Inputs

There are three inputs to the Power Supply Module:

- RAWBATT is the voltage directly from the battery pack.
- XONOFF is taken low through the front panel switch to turn the unit on.
- XPWR_KILL is taken low by the CPU to turn the unit off when battery voltage is too low.

Outputs (other than power)

- XPWR_RESET is a warning signal from the CPU +5V supply to the CPU indicating that power loss is imminent.
- XSAF_RESET is a warning signal from EPU +5V supply to the EPU indicating that power loss is imminent.
- TEMPSENS is a measure of internal temperature
- XPWR_KILL (above).

FUSEBATT and VSAVE_PWR are always available so long as a battery pack is inserted. When a pack is removed, FUSEBATT is also removed, but VSAVE_PWR remains for several hours to support the real time clock.

Two of the voltages are stacked on top of the battery pack voltage: P8TN_PWR and RCDR_PWR. The CRT heater power floats between SWBATT and RCDR_PWR.

The 5000 volts for the CRT anode is provided by a separate voltage multiplier whose input is provided by the Power Supply 900 V Peak to Peak.

Voltages in the table are available at the same time. When the battery pack is removed, these voltages remain for a short time so that the microprocessors can complete their essential tasks.

The unconditioned battery voltage RAWBATT is used directly by the stimulator board to provide high current for pacing pulses and high voltage capacitor charging.

POWER SUPPLY VOLTAGE CHART

Output	Voltage	Use of Output
PFIV_PWR	+5	CPU
SAF5_PWR	+5	EPU
PSIX_PWR	+6.2	5 V regulators, CRT G1
MFOUR_PWR	+4.2	Yoke deflection
PFOUR_PWR	-4.2	Yoke deflection
PTWLV_PWR	+11.6	Analog, yoke deflection, isolated power for ECG
MTWLV_PWR	-11.6	Analog, yoke deflection
SWBATT	+9 to +12	Stimulator power, Heater
RCDR_PWR	SWBATT + 5.5	Recorder, Heater
P8TN_PWR	+21	Patient relay closure
PCATH_PWR	+40	CRT intensity
FOCUS_250	+250	CRT G2
FOCUS_100	+150	CRT G4
HIGH VOLTAGE	900P-P	HV multiplier

3. DIGITAL BOARD

The Digital Board includes digital and analog circuitry controlled by two microprocessors, the CPU and the EPU. The functions of the board include:

Real-Time Device Control

- ECG front end
- Pace/Defib
- CRT display
- Strip chart
- Power supply
- Beeper
- Option modules

System Functions

- Non-volatile memory
- Real time clock
- ECG signal processing
- System status monitoring

User Interface

- Front panel controls
- Electrodes controls

Safety Functions

- Safety monitoring of the CPU by the EPU.
- Redundant measurement of functional safety parameters

Calibration and Test

- Calibration
- Self tests
- Safety tests

Architectural Overview

The CPU and EPU use separate address and data busses. Communication between CPU and EPU is on a single line network which is also shared with external modules through the Option Module Port. An I/O controller gate array shares bus with the CPU and provides device control latches and data input latches as well as timing and other functions under read/write control of the CPU. The CPU also has bus control of A/D and D/A for analog control and measurement and bus control of latches for control of other devices such as the strip chart recorder.

A CRT display controller gate array has its own RAM/ROM bus and functions as a dedicated controller. The EPU controls the display controller by writing to a CRT control latch and by writing to a bi-directional bus chip that allows the EPU and CRT controller buses to be common. The EPU also has bus control of parallel to serial and serial to parallel data conversion for ECG data and control.

3a. CPU

The CPU (U27) is the central control unit for the ZOLL 1600 instruments. It receives information from the front panel switches and from signals internal to the instrument. After making decisions based upon the information received, it controls the operation of functional blocks such as the pacer output, defibrillator output, the strip chart recorder, the real time clock, and the non-volatile memory.

The basic hardware functional blocks associated with the CPU are as follows:

1. Front panel I/O control
2. Microprocessor (CPU, ROM, RAM, NVRAM, memory control)
3. Real time clock
4. Input and output latches
5. Analog-to-Digital conversion
6. Digital-to-Analog conversion
7. Serial communication

All the user inputs from the front panel are received by the CPU. The CPU then distributes the appropriate signals as required.

The CPU passes control requirements for ECG to the EPU by way of the serial communication link.

Operation of the pacer function is performed by having all the user setup controls received by the CPU. Signals such as pace current amplitude and pace pulse rate are converted from analog signals to digital data for microprocessor operation and manipulation.

The pacer operates as an output device controlled by the CPU. Pace current amplitude is set through a D/A converter (VCTL) and pace pulse width and rate is set by the gate array signal XPWRENB. See section 4b.

The defibrillator charging and discharging is controlled by the CPU. The CPU receives all the user inputs and performs all the required logic for safe operation of the defibrillator except for the independent safety checks performed by the EPU. Diagnostic functions concerning the proper high voltage capacitor charging and operation of the defibrillator are provided by the analog signal VCAP representing the high voltage capacitor voltage.

The defibrillator energy delivered is calculated by the CPU from a signal derived from the wave shaping coil and transmitted via the Pace/Defib board.

CPU hardware

The CPU circuits center on a 8031 microcomputer (U27).

The CPU performs several checks on internal circuits to be sure that they are running properly including all memory locations, voltage reference and the real time clock.

All digital input signals to the CPU go to individual latches or to the on board gate array (U21). These signals are read into the RAM memory. Digital output control signals are provided on discrete latches or on the gate array (U21).

The real time clock (U58) retains date and time. When the instrument is turned off, the real time clock operates at reduced voltage and draws insignificant current from the battery. When the battery pack is removed, a large capacitor provides operating power to the real time clock for eight or more hours.

The CPU controls and monitors all the controls and switches on the instrument and the electrodes or Multi-Function Cable and accessory cables. (Option module) The front panel switches are read into a matrix array of rows and columns (SWCOL0-3 and SWROW0-5) that the CPU can read through the gate array to determine which switches have been selected. The CPU also monitors the presence and identification of option modules and accessory cables.

The gate array has several independent functions collected into a single LSI chip. Several of the internal functions have been described as they pertain to specific functional operations of the CPU. Additional functions in the gate array are clock divider circuits, pacer timing and control signals and an independent watchdog timer and reset circuit.

The watch dog timer provides functional safety in the event of a failure in the microprocessor program execution. If the microprocessor fails to update the watchdog timer every 4.5 msec the timer will reset the CPU.

The analog section of the CPU circuit consists of analog-to-digital (A/D) conversion and digital-to-analog (D/A) conversion. The (A/D) section has an 8 bit successive approximation converter (U16). Two multiplexes (U6 and U8) provide 16 analog inputs:

Channel 0	BEEP/PWR_STROBE	beeper
Channel 1	PADMON	Shock switch status
Channel 2	RPOT	Pacer rate-setting potentiometer voltage
Channel 3	V_PADPOT1	Not used in the ZOLL 1600
Channel 4	VCAP	high voltage capacitor
Channel 5	V_PADPOT2	electrode type
Channel 6	IPOT	Pacer output current setting potentiometer voltage
Channel 7	SWBATT	battery voltage

Channel 8	ECGOUT,VCTL_LOOP	test
Channel 9	V_X, V_Y_LOOP	test
Channel 10	TEMP_SNS	temperature
Channel 11	CHARGE	defib charge button
Channel 12	CATH_LOOP	test
Channel 13	IPEAK	defib discharge current
Channel 14	PACE_ID	test
Channel 15	25V_REF	voltage reference

The reference voltages required for both A/D and D/A are provided by 5V_REF2, derived from 25V_REF (U20).

The D/A section consists of an 8 bit CMOS converter (U22) and a buffer stage for gain and offset using op amps U23 & U25. The output signals are: ECGOUT, used for the analog 1 volt per volt ECG replica, and VCTL, the pace pulse current control signal.

A single bi-directional line is used for both transmission and reception of data between the CPU and the EPU. The connection is direct between CPU and EPU and is buffered and converted to two separate transmit and receive lines at the option module connector.

The EPU is concerned with most of the operation of ECG processing, the CPU controls ECG calibration.

3b. EPU

The EPU:

- processes ECG data received from the Analog board
- controls the presentation of messages and ECG data to the CRT
- provides an independent safety monitor of pace and defib functions.

The basic hardware functional blocks associated with the EPU are as follows:

1. Microprocessor (EPU, ROM, RAM, memory control)
2. Input and output latches
3. Serial-to-parallel data conversion
4. Parallel-to-serial data conversion
5. Serial communication

The CPU passes ECG control data to the EPU by way of the serial communication link. The EPU controls selection of the ECG leads such as electrodes, lead I, II, or III and controls ECG size for display on the CRT.

Four lines provide the interface to the isolated ECG front end:

- ECG_DATA_IN — Serial eight bit ECG data.
- EDATA_OUT_CLK — Data clock for both directions of data.
- ECG_LATCH — Used to set the eight bits of the isolated side latch
- ECG_DATA_OUT — ECG control

Refer to the Analog board, ECG section 5a, for a description of these signals.

The display of data on the CRT is accomplished in two steps. First, The EPU formats the ECG data and the messages it has received from the CPU, then loads this data into a display RAM. The CRT gate array controller (U52) will then retrieve this data from RAM and use it to control the writing of messages and ECG data on the CRT. The CRT is refreshed every 16 msec during which 8 msec is used to write 1000 ECG data points and 8 msec is used to write characters.

In character mode, the controller uses the display RAM data to provide outputs of: X position, Y position, and intensity for each step that forms a vector on the CRT monitor. Switch selectable filters on the X and Y DACs provide the correct compensation for the two modes of operation, character writing and ECG trace. The DAC outputs drive current amplifiers on the Analog board which control the CRT beam deflection. Character beam intensity is controlled by modulating a single intensity bit to form a constant beam brightness independent of the beam speed. An intensity data byte sets the baseline brightness of the trace by controlling the CRT cathode voltage.

The baseline intensity is set with one intensity bit. During rapid transitions the beam appears dimmer and needs an enhancement to produce a uniform beam intensity. An analog circuit intensifies the beam during rapid vertical movements. An additional intensity bit is used to form a bright marker on the ECG trace when an R-wave is detected in the SYNC mode of machine operation.

Control of the CRT gate array is accomplished by four control lines from the EPU to the gate array and a bi-directional data bus chip. The EPU can set an address location for either the CRT RAM or ROM by setting registers in the gate array using the bi-directional data bus chip (U44). With the address location set, the bus is used to read or write from either the ROM (U55) or RAM (U56).

A status line EOMC is returned from the gate array to indicate when a string of data is completely transferred from memory to the analog circuits.

Gate Array Functions

The CRT gate array (U52) is designed to operate independent of EPU (U3). This allows the EPU to service other tasks while the gate array drives the CRT tube deflection circuits.

To display data on the CRT tube, the gate array program counter is set to a starting address. When the array starts execution, it sequentially retrieves control words from memory which are executed until the end of message (EOMC, U3-30) command is retrieved. The array is halted until the EPU initiates another execution.

The gate array has five control registers used to drive the CRT deflection circuits, to control the beam intensity, and to set up operating modes such as clock rate and filter selection (trace vs character).

The five registers are defined as follows:

- X latch - 8 bit data to drive a DAC for horizontal beam deflection.
- Y latch - 8 bit data to drive a DAC for vertical beam deflection.
- Intensity Latch - 8 bits (U52-1 to 6, 9,10) of individually elected lines to set beam intensity and clock rate.
- Blanking shift Register - An 8 bit word is shifted out serially (U52-7, BENBO) for each new X and Y data word. This is used only during character display.
- Attribute Latch - 4 bits individually selected to control operating modes such as end of message (EOMC), blink enable, filter control (EXTR3).

The gate array can read the ROM (U55) and is capable of reading and writing RAM (U56). The RAM is used to store 1000 bytes of ECG data with an R-wave marker, store a sequence of starting ROM addresses for characters, store ROM addresses for programmed wait and move instructions, and provide a stack for subroutine operations.

To display a trace on the CRT, the gate array will retrieve a single Y data point from RAM every 8 µsec and latch it into the Y DAC register. Every 32 µsec the X DAC is incremented by one count having started at a count of 00Hex (left side of CRT display). Each Y data point also has an intensity and blanking byte to control the beam intensity. When an R-wave is detected, the sixth intensity bit (slew) is set high to further intensify the beam. For normal trace intensity the fifth intensity bit (Intfy) is set high. The blanking byte is not used in the trace mode.

During the character display mode, the gate array retrieves the character generation commands from the ROM every 4 µsec. Each command will provide an X and Y incremental movement and a blanking byte (BENBO) to control intensity. The blanking byte is modulated during each step command to provide a constant beam intensity.

To properly display ECG trace and characters, the clock rate is changed and the analog deflection filters are switched. The clock rate (OCLK) is controlled with the two high order bits of the intensity byte (EXTR1 and EXTR2) to provide 4 MHz for character and 2 MHz for ECG trace. The filter selections are controlled by the attribute bit (EXTR3).

4. PACE/DEFIB STIMULATOR BOARD

The Stimulator Board includes circuitry for patient stimulation in two modes of operation: defibrillation and pacing.

4a. DEFIBRILLATOR

The Defibrillator circuit is responsible for three major functions:

1. charging the high voltage capacitor to the level specified by the front panel setting.
2. providing feedback on the high voltage capacitor's voltage level.
3. discharging the high voltage capacitor energy through electrodes or the Multi-Function Cable.

The Defibrillator portion of the stimulator Board is active only when the front panel switch is set to DEFIB ON.

Charging

A charge may be initiated by pressing the Analyze/Charge button on the Main Control Panel. When the CPU detects a charge request, it controls the charging process as follows: The defibrillator circuits begin charging the high voltage capacitor to the target voltage for the energy selected from the front panel indicated on the CRT. The CPU continuously monitors the VCAP signal to ensure that the high voltage capacitor charges at the proper rate. Improper operation results in an internal dump and display of a warning message. When the target voltage is reached, the CPU initiates a continuous beeper tone to indicate that defibrillator is ready to discharge. The target energy level is displayed on the CRT screen.

In Semi-Automatic operating mode, the defibrillator holds the energy for 15 seconds, with the energy level being refreshed as necessary. The last five (5) seconds of the hold period is indicated by an intermittent beep tone. After the 15 second period, if the defibrillator has not been discharged, the energy is internally dissipated by the safety relay (XSAFREL). In Manual operating mode, the charge is held for 60 seconds, and the last ten (10) seconds is indicated by an intermittent beep tone.

Shock

A discharge is initiated by pressing and holding the **SHOCK** button on the Main Control Panel. This provides voltage to the patient discharge relay coil and notification to the CPU through the PADMON signal. The CPU then controls activation of the patient discharge relay. There are two exceptions to immediate discharge: operating in SYNC mode and operating with the Multi-Function Cable. In SYNC mode the discharge occurs near the peak of the ECG QRS wave. With the Multi-Function Cable, an open circuit test is first performed. If an open circuit is detected, the discharge is not allowed and the message "CHECK ELECTRODES" is displayed on the CRT.

Energy delivered to the patient goes through a wave shaping inductor to provide a damped sinusoidal defibrillator waveform that meets the AAMI Standards.

When the patient discharge relay is deactivated and the high voltage capacitor returns to system side, the safety relay is closed to internally dissipate any remaining energy .

If the ZOLL 1600 is in the self-test mode, the energy is delivered internally. The microprocessor calculates the actual delivered energy from the current waveform and displays a TEST OK message on the CRT, if the criteria for a successful "self-test" have been met. If the criteria are not met, a TEST FAILED message is displayed.

DETAILED CHARGING OPERATION

Initiating High Voltage Capacitor Charging

The CPU controls several signals that are used to initiate charging the high voltage capacitor. Once the stimulator board has received the signals, the board will charge the high voltage capacitor with a Pulse Width Modulator (PWM) controller (U1). The CPU will continue to monitor the changing VCAP signal to ensure proper charging operation.

All the following conditions must be satisfied before the high voltage capacitor can be charged.

1. XSAFE hi — No safety hazard detected
2. XPWR_RESET hi — Power on
3. P/XD low — Defib mode
4. XSAFREL low — Safety relay open
5. XPATREL hi — Discharge buttons not active.
6. XPWRENB low — PWM enabled

To provide safety and to improve battery operating time, the stimulator circuits are only powered when the main selector switch is in the Pace or Defib position. A high level on the signal XPWR_RESET and XSAFE will close Q100 providing power (+12) to the stimulator board.

The defibrillator capacitor is shunted for safety reasons with a resistor and relay to internally dissipate any energy remaining. When charging is initiated by the CPU, this relay is opened by providing a low level on signal XSAFREL.

P/XD sets the defib mode by disabling the pace energy driver, enabling the defib high voltage transformer driver (Q7) and setting the basic ramp time for the PWM at U1 pin 7 to set the operating frequency for flyback transformer T3.

The CPU can control the charging rate of the high voltage capacitor to improve battery efficiency by changing XLORATE. This signal affects the ramp time for the PWM by changing the capacitor to the ramp timing circuit.

When the CPU has completed set up for initiating high voltage capacitor charging, the CPU enable signal XPWRENB is set low. This signal will initiate the PWM controller. The three signals XPWRENB, XPATREL, and XSAFE are logically interlocked so that the proper combination must be present for charging to occur.

Charging Operation

The high voltage capacitor is charged by converting the system battery voltage to a pulsed high voltage by way of transformer T3. Control of this function is provided by the PWM controller (U1). It provides a basic operating frequency signal that is used to switch transistor Q7 providing current in the primary windings of the transformer T3. Efficiency is improved in charging by providing feedback of the current into the high voltage capacitor on every cycle of Q7 switching. The PWM controller is inhibited on each cycle until the high voltage capacitor current is nearly zero. This control is provided by the U3 op amp circuit. U1 pin 3 is inhibited with a high level when significant capacitor current is present.

When the high voltage capacitor is charging, the EPU independently monitors the capacitor voltage through signal VMON. If an improper level is detected, the EPU will halt operation by setting XSAFE low. This stops the PWM controller and removes power (+12) from patient relay coil, safety relay, and flyback drive.

Discharging the high voltage capacitor

Activation of the patient relay to discharge the HV capacitor is a two step process. The power provided to the patient relay is routed through the discharge switch on the Multi-Function Cable. The CPU then senses when the **DISCHARGE** button is pressed with a signal called PADMON. When the CPU has decided that all other conditions have been met, such as in the SYNC mode, it activates the signal XPATREL and DISCHARGE. This signal drives Q12 and Q102 which activates the patient relay.

When the patient relay activation is complete, the CPU releases the XPATREL and DISCHARGE signals and allows the patient relay to return the capacitor terminals to the ZOLL 1600 system side. Several hundred milliseconds later, the safety relay is closed to ensure the high voltage capacitor energy is completely dissipated.

4b. PACER

The Pacer circuit produces and delivers user-controllable pace pulses to the pacing electrodes. Pacing is initiated when the front panel switch is turned to PACE and the OUTPUT and RATE controls are set. Pacing current amplitude is constant during the pulse and is determined by the position of the front panel PACER OUTPUT dial. Pacing pulse rate is determined by the position of the front panel PACER RATE dial. The pacing pulse duration is fixed at 40 msec.

The CPU provides five signals used by the Pacer circuit. They must be as indicated for pace pulses to be generated:

1.	XSAFE hi	No safety hazard detected (EPU)
2.	XPWR_RESET hi	Power on
3.	P/XD hi	Pace mode
4.	XLORATE low	Pace charging rate
5.	XPWRENB low	PWM enabled during pulse
6.	VCTL	Sets current amplitude

The CPU provides two signals to control the pacing pulse:

VCTL sets the pacing current amplitude. It is an analog signal derived from the position of the front panel pace pot PACER OUTPUT. Current sense transformer T1 and operational amplifier U3 measure actual pacing current (VPACE) and compare it to VCTL to provide loop control.

XPWRENB is a digital signal turned on and off by the CPU to start and stop the pacing pulse. The CPU sets the pace pulse duration by the XPWRENB on time and the pace pulse rate by the XPWRENB on-to-on interval.

Outputs

The signal LEAD OFF is sent from U10 to the CPU when the pace current times the patient resistance exceeds about 300V ± 15%. This is used to detect Pacing leads off.

The pace pulse output goes to the pacer output connector on the Multi-Function Cable.

Independent safety monitoring is provided by the EPU. An independent measure of pacing current is provided in the signal VSNS. It is derived from a second current sensing transformer T2 and op amp U8. In Pace mode VSNS must indicate the selected pacing current. If the expected condition is not reached, the EPU stops the PWM controller and removes +12 volts by way of XSAFE.

5. ANALOG BOARD

The Analog Board consists of two sections, ECG, and CRT deflection.

5a. ECG

The ECG has a system circuit side and a patient isolated side. On the patient isolated side there are two inputs for ECG signals. Multi-Function Electrode input protection is provided by series resistors and voltage limiting components. The three lead ECG input is protected with voltage transient suppressors, the lead select relays, series resistors, and diode clamps. The three lead input is sensed for a leads off condition. Both ECG inputs (leads and Multi-Function Electrodes) follow the same signal conditioning path after the lead select relays. The signal path consists of RF input filtering, an instrumentation amplifier, a slew limiting stage, a gain and low pass stage, and then an analog to digital serial data conversion for transmission over the patient isolation barrier to the system side. Other circuits on the isolated side include leads off, hi slew detection, gain and bandwidth selection, and drive circuits for the lead select relay.

The system side circuits consist of minimal signal conditioning and the power supply drive. The isolated power supply runs at 67 kHz from the +11.6 V regulated supply.

Input Protection

The ECG patient connections are protected with voltage transient suppressers at each of the three input leads and at the Multi-Function Electrdoes input. A second level of protection for the op amp inputs is accomplished with series input resistors and diode clamps to the power supply rails. Current source resistors (R7, R8) are used for ECG leads off detection. Protection between the Multi-Function Electrodes inputs and the three lead inputs is achieved by the series resistors, Zener diodes (D21, D22), MOVS (M1, M2, M3), and the lead select relay (K1). The MOVs limit the voltage if an external defibrillation voltage is applied from the electrode to any of the three ECG leads.

Lead Selection

Inputs from the ECG amplifiers may come from the three standard ECG leads or from the Multi-Function Electrodes. These inputs go to the lead select relay (K1,) and selection multiplexers (U6, U7) to provide the standard lead configurations of lead I, II, or III and to select the electrodes input. The relay also provides isolation of the electrodes inputs and the three ECG leads.

The lead select relay is of a latching configuration with the relay having a separate set and reset coil. These coils are driven by FET switch Q2 and latch bit LEAD_DRV. The relay state selected is determined by latch bits LEAD(0) and LEAD(1). Multiplexer select bits are provided by the output of latch U4; bits are latched via LEAD (1) and FET switch Q2.

The multiplexer outputs are filtered prior to the first stage instrumentation amp (U2). The instrumentation amp configuration provides excellent common mode rejection by using precision matched gain resistors. The first stage instrumentation amplifier has a gain of 14. The second stage after the instrumentation amplifier (U3) provides a dual function. First, it limits the slew rate of the signal before it can pass to subsequent stages. This happens when the input signal exceeds 1 v/sec due to events such as internal pace pulses or noise. The second function is to provide a signal to the high slew detection circuit (U5) when high slew signals are present.

Leads Off

Disconnected ECG leads on RA, LA, and LL leads are detected. For the three ECG inputs, the leads off status is detected when current source resistors (R7, R8) drive the input voltage out of bounds. It is also possible to get a leads off message when a signal larger than approximately 0.5 volts is applied to either the three ECG leads or the electrodes input.

The leads off status is detected from each of the two op amps (U8a, U8b) and output level of the instrumentation amp (U1B). This will cover all possible combinations of removed leads. These three signals are diode OR'ed together and are the input to the leads off detection circuit (U15). When either of the two input op amps drops below approximately -8.75 volts or if the differential op amp stage output exceeds +/- 8.75 volts the leads off signal is sent to the EPU by clamping the serial data signal (ISO4). During electrode monitoring, leads is detected by the electrode impedance measurement circuit.

Hi-slew

The second stage amplifier of the ECG signal provides a slew rate limit of 1 volt/second by saturating the ECG signal above this slew rate, for example, when there is a pacing pulse.

Electrode Impedance Measurement

The electrode-to-electrode impedance is measured by injecting a low-level, high-frequency AC current into the electrodes via transformer T2. The induced voltage at the electrodes is sensed via a demodulator circuit (U24 and peripheral components) and measured by the EPU on its A/D, ACH7.

ECG Data Interface

Four optoisolators provide the interface to the isolated side:

Output	ECG_DATA_IN	Serial eight bit ECG data.
Input	EDATA_OUT_CLK	Data clock for both directions of data.
Input	ECG_LATCH	Used to set the eight bits of the isolated side latch:
Input	ECG_DATA_OUT	ECG control word
	two bits:	four lead combinations I, II, III, Electrodes
	three bits:	eight ECG amplifier gains
	two bits:	three bandwidths
	one bit:	LEAD_DRV, strobes lead select relays.

System Side

Power Supply for Patient Isolated Circuits

The supply chopper signal is provided by the CPU gate array at 67 kHz. The signal drives the power chopper (U21).

5b. CRT DEFLECTION CIRCUIT

Deflection

Two similar deflection circuits receive X and Y deflection analog voltages from the EPU and convert them to deflection currents to drive the CRT beam. These circuits are based on operational amplifiers which convert input voltage to current in the range of 0.6 amps and include filtering to remove DAC steps and provide compensation.

Both circuits operate in high and low power modes to conserve battery capacity. With slow beam movement, power is derived from +/- 4.2 volt supplies. When the beam is required to move rapidly, power is switched momentarily to +/- 11.6 volts to achieve more rapid change in deflection coil current.

CRT Intensity Control

The intensity control circuits have three operational sections. They are a high slew signal which is a rectified signal proportional to beam rate of change, INT_2, a high slew inhibit switch, and an adjustable current source (Q15) to control cathode voltage.

To display an ECG trace, there are three intensity controls implemented. The proper baseline intensity is selected with the intensity bit (INTFY). When vertical deflection is fast, the beam speed on the phosphor causes the trace to appear dim so an analog high slew signal proportional to beam speed is used to increase the beam intensity, resulting in a uniform ECG trace display. To indicate an R-wave detection by the CPU, an additional intensity bit (SLEW) is used to substantially increase the beam intensity. This results in a very bright segment of trace where the R-wave was detected.

To display characters only BENBO is used to control the adjustable current source and INT_2 is turned on to prevent the analog beam slew detector circuit from having an effect.

6. MEDICAL REPORTING MODULE

The Medical Reporting Module, hereafter referred to as the MRM, contains two major printed circuit board assemblies which are connected by a 70-pin connector set P1 and J1:

MRM Section I - Contains PCMCIA card interface circuitry, voice prompt generation hardware, audio mixer, audio power amplifier, and isolated RS-232 interface hardware.

MRM Section II - Contains a microcontroller system which includes an MCU, gate array, ROM, and RAM. It also includes the power supplies, the MRM keypad interface, serial host interface, a UART for RS -232 communications, Audio DSP Board interface, and the keyswitch interface.

Optionally, the MRM can record ambient audio data to the PCMCIA card if the Audio DSP printed circuit board assembly is installed. This contains a microphone preamplifier, audio processing circuitry consisting of filtering, automatic gain control, and Analog-to-Digital conversion, and a Digital Signal Processing IC known as a "Vocoder". This assembly converts the ambient audio data recorded by the microphone into a compressed digital format for efficient storage in the PCMCIA card.

MRM Section II

The microcontroller system centers on an Intel 80C198 microcontroller (MCU) U12 running at 16 MHz. This MCU supports a 16 bit address bus. The low order address bits and the 8 bit data bus are demultiplexed by the address latch U10. The EPROM U7 is 64K bytes in size. The static RAM U3 is 32K bytes in size. A gate array U6 contains address decoding, data latches, the MRM keypad scanning logic, and a timing system which runs from the 2.048 MHz crystal Y1, and creates timing signals to operate the Audio DSP Board. The MRM reset system is fairly complex, as it allows the MRM module to be reset by the host processor via the AUX_RST signal, by the power supply monitor U4, or by a watchdog timer in the MCU itself. There is a separate reset system to support the voice prompt system on the MRM Section I PCB. This consists of a power supply monitor U5 and the VP_RESET- signal from the gate array U6. This reset system allows voice prompts to complete sounding even if the MRM module is being held reset by the host, which is what happens during a defibrillation event.

The MCU contains an A/D converter which is used to monitor the 12V PCMCIA card programming power supply U16. The host interface is handled by a serial communications port in the MCU which communicates with the host's option module interface bus. The signal AUX_TX brings serial data to the MRM. The signal AUX_RX carries serial data from the MRM. The signal XEPU_INT is an interrupt which is used in the communications format between the MRM and the host. The signal AUX_RST was described in the reset system description. The KEYSWITCH signal has no active circuitry associated with it in the MRM module. The MRM Section II PCB acts to pass the KEYSWITCH signal to the key switch. This allows the ZOLL 1600 to be switched to manual mode even in the event of an MRM module failure.

The UART U9 is a 16C550 type, which provides logic level signals to run the RS-232 interface located on the MRM Section II PCB, or a presently undefined telecomm interface which would connect at J9. The UART runs from 1.8432 MHz crystal Y2.

The power supply system consists of U15, which is a switching type power supply that converts the unregulated VBATT voltage of 9-12V into a regulated 5V. The VBATT is actually SW BATT from the 1600 platform. Another switching supply U16 converts the 5V into 12 V for PCMCIA programming.

MRM Section I

The PCMCIA interface consists of address latches U14 and U15, which hold "page" address bits A12-A25, tri-state buffers U17 and U18 which carry the lower address bits A0-A11, and bi-directional data buffer U13. Card detect signals C_CD1- and C_CD2- cause the FET Q2 to turn ON and allow the +5V power supply to the PCMCIA connector. A switching matrix U1 provides the proper programming voltage (5V, 12V, or high impedance) C_VPP to the PCMCIA connector. Several of the inverters of U9 and a tri-state buffer from U10 provide the proper PCMCIA reset signal C_RESET. All of the PCMCIA signals are transferred to the PCMCIA connector PCB through J2.

The voice prompt generator U16 runs from 64 KHz crystal Y1. U16 and the other analog circuits on this PCB derive their 5V power supply through resistor R20 and capacitor C13 to reduce digital noise. When commanded by the MCU to sound a voice prompt, the voice prompt generator IC reads digital data from EPROM U19 and converts the data to an analog signal at VP_AUDIO. This signal is buffered and filtered by U11, which also acts as a mixer to allow DSP_AUDIO and the undefined TELECOM_AUDIO to sound through the MRM speaker.

The audio power amplifier U20 derives its power from the unregulated VBATT. Its outputs AUDIO_OUT+ and AUDIO_OUT- drive the speaker. These signals are of the push-pull type, which appear as the inverse of each other, biased at approximately half of the VBATT voltage. This arrangement allows maximum power efficiency when driving the speaker. The power amplifier can be shut down by the signal AUDIO_EN to save power when not in use by turning the FET Q4 OFF. The VOL_CNTL signal is a DC level which controls the volume of the audio output. This signal is derived from the mark-space ratio which is produced on the PWM signal by the MCU. The PWM signal is filtered to a DC level by R38 and C15, buffered by U12, and then sent to U20 to control volume. The charge in capacitor C15 can be held by the signal PWM_EN- to allow a voice prompt to complete sounding even if the MRM module is reset by the host, which occurs during a defibrillation event. The signal VP_BUSY is used to mute the audio output by pulling VOL_CNTL to ground through Q3 whenever a voice prompt is not sounding. This feature can be disabled by VOL_EN when the speaker is used for other purposes.

The RS-232 system allows data previously recorded onto a PCMCIA card to be downloaded to a personal computer. Logic level RS-232 signals from the MRM Section II PCB are converted to optocoupler drivers by U7. From the optocouplers U5 and U6, the signals are converted to RS-232 levels by U2. Signals coming in from the RS-232 interface are converted to optocoupler drivers by U2, sent through optocouplers U3 and U4, and converted to logic level signals by U7. Transformer T1 is driven by U7, and produces approximately +7V and -7V required by U2 to drive the isolated RS-232 interface which exits the MRM module via the outer 4 pins of the RJ-45 connector. The isolation is required to ensure that any leakage current or errant voltages from uncontrolled computer equipment connected to the RS-232 cable do not create a hazardous condition in the ZOLL 1600. The RS-232 system is shut down to save power when not in use by the signal RS232_EN-.

Audio DSP Board

Audio signals from the microphone are received via connector J10. A pseudo-ground of 2.5V called VIRT_GND is created by U5 to allow AC analog signal processing and to drive the microphone. The audio signals are amplified by U5, and then filtered by U4. U4 creates a two-pole bandpass filter from 300Hz to 3KHz to filter environmental noise out of the voice band. AGC amplifier U3 can both amplify and attenuate incoming signals to keep an AC level appropriate for analog-to-digital conversion at the signal AGCOUT. CODEC U1 performs the analog-to-digital conversion and sends serial data to Vocoder U2. All of the analog circuitry on this PCB derive their 5V power through resistor R6 and capacitor C6 to reduce digital noise. Vocoder U2 performs DSP which compresses the data into 25 bytes of data every 20 mSec. The Vocoder runs at 30 MHz from third-overtone crystal Y2, and obtains its other timing signals SYS_CODEC_SYNC- and 2.048 MHz from the MRM Section II PCB.

7. STRIP CHART RECORDER

The strip chart is a General Scanning AR-42. Data are transferred in either direction on an eight bit bus. Control lines are:

STR_XWR	writes data to strip chart
STR_XWRRDY	ready to receive data
STR_XRD	reads data from strip chart
STR_RDRDY	data ready to be read
STR_ERR	error has occurred
XSTR_RST	resets strip chart
STR_SYNC	generates interrupt to CPU
STR_RDBK(0)	indicates which status word is available
STR_RDBK(1)	indicates which status word is available

The strip chart is controlled by the CPU and receives all its data from the CPU. The CPU buss is made common to the strip chart through the bi-directional buss chip U15. The recorder communicates STR_SYNC (interrupt) and two status bits indicating which of four status bytes is available direct to the CPU or CPU gate array. The CPU provides a direct line to reset the strip chart (XST_RST). Read and write signals are provided only when needed. Three control signals, STR_XWRRDY, STR_XRDRDY, and STR_ERR are provided when strip chart control latch U24 is selected by the CPU.

SECTION V
SCHEMATIC DRAWINGS

ZOLL 1600 schematic drawings are included here to supplement the information presented in:

- Section III, Troubleshooting
- Section IV, Functional Descriptions
- Section VI, Component Layout Drawings

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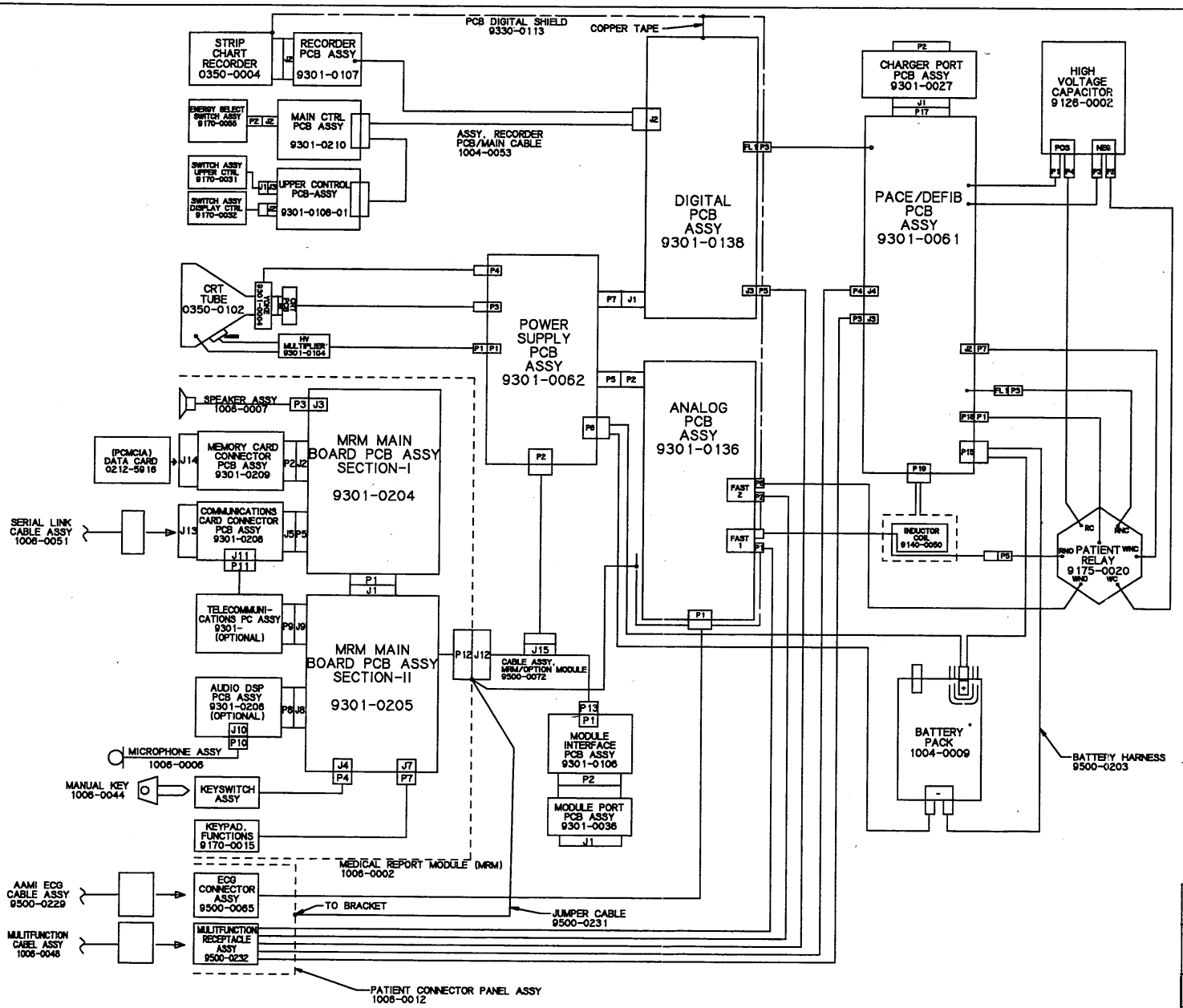
PCB DIGITAL SHIELD 9330-0113
COPPER TAPE
STRIP CHART RECORDER 0350-0004
RECORDER PCB ASSY 9301-0107
MAIN CTRL PCB ASSY 9301-0210
UPPER CONTROL PCB-ASSY 9301-0108-01
ASSY, RECORDER PCB/MAIN CABLE 1004-0053
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SPEAKER ASSY 1006-0007
(PCMCIA) DATA CARD 0212-5918
MEMORY CARD CONNECTOR PCB ASSY 9301-0209
MRM MAIN BOARD PCB ASSY SECTION-I 9301-0204
SERIAL LINK CABLE ASSY 1006-0051
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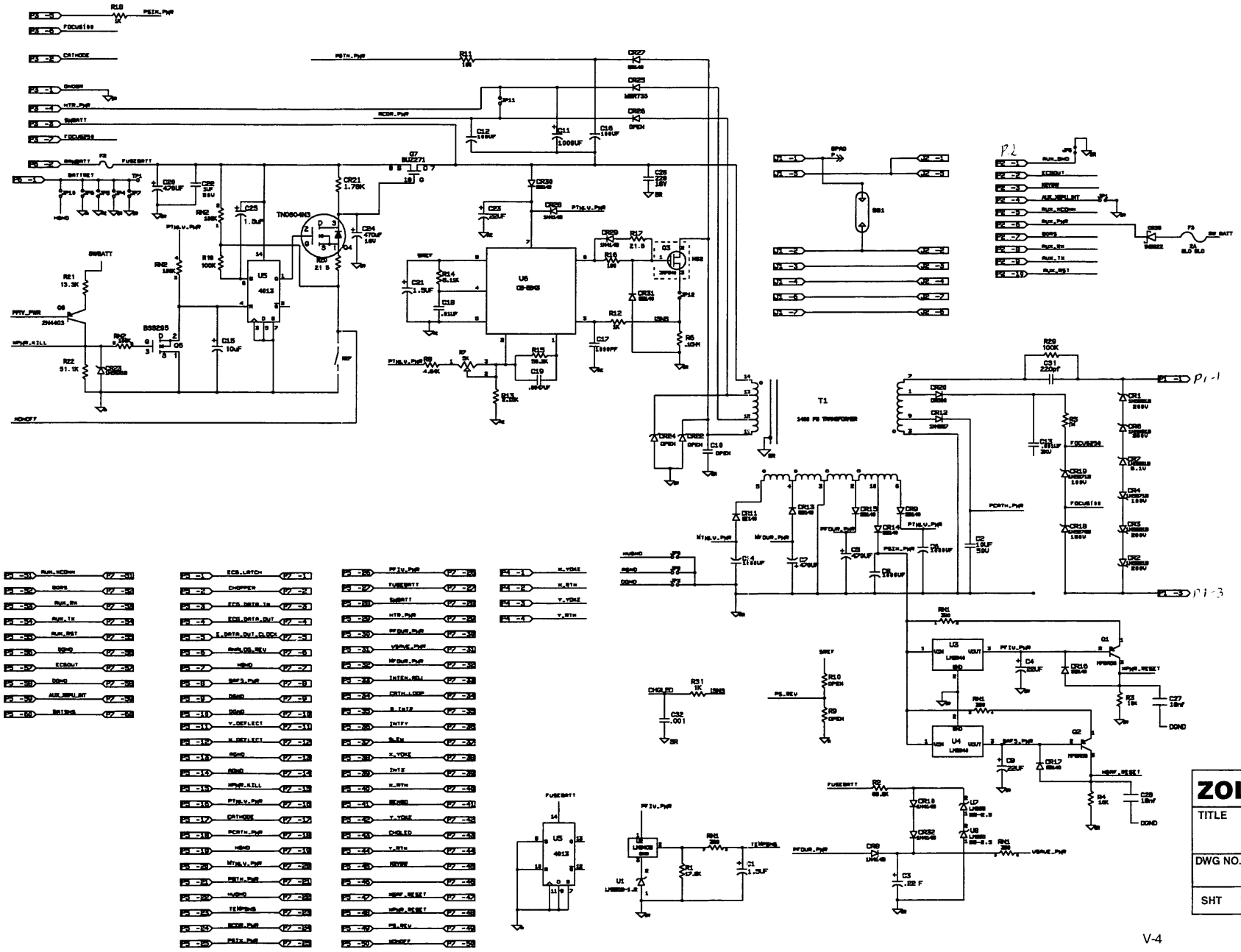
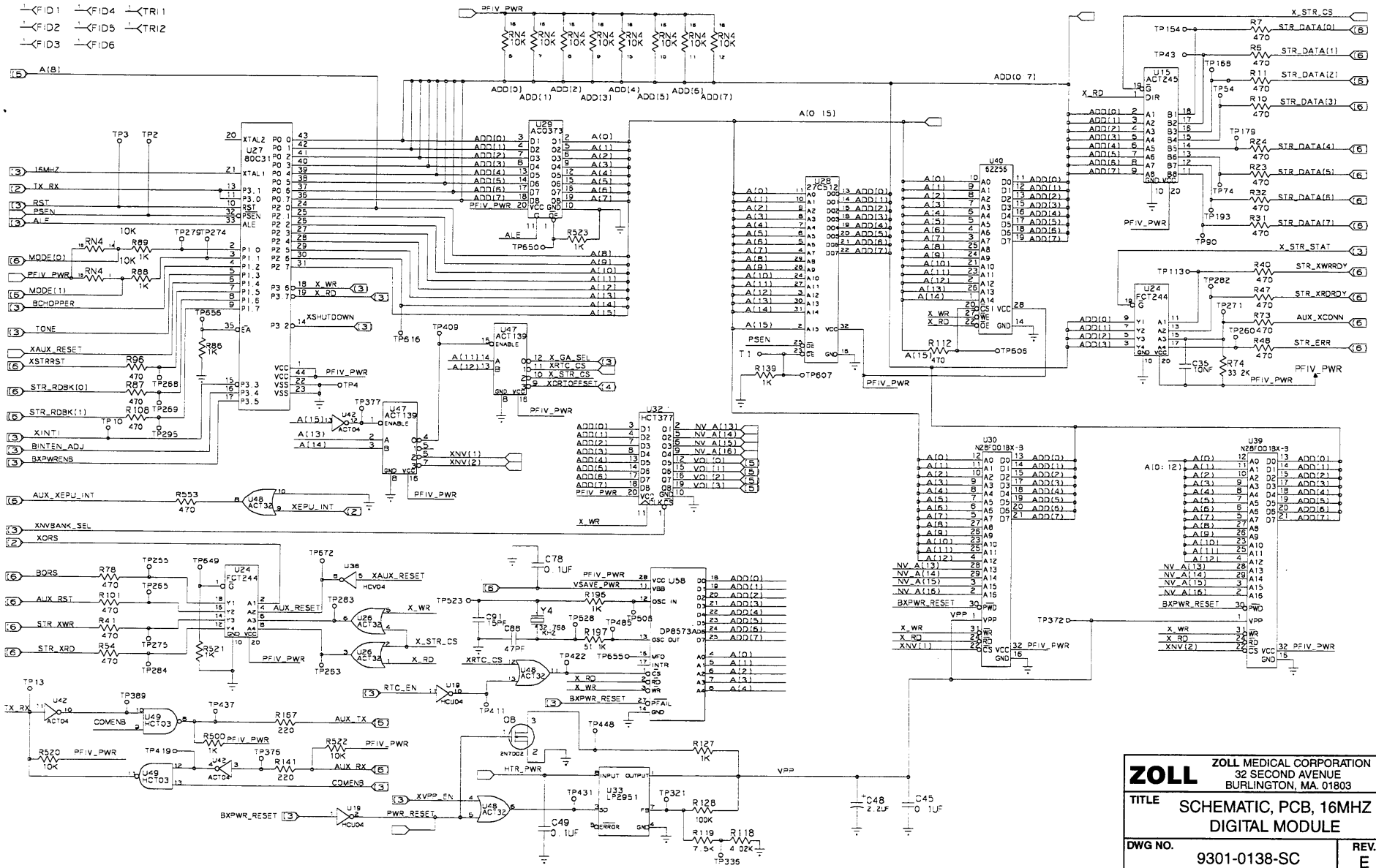
MICROPHONE ASSY 1006-0006
MANUAL KEY 1006-0044
KEYSWITCH ASSY
KEYPAD, FUNCTIONS 9170-0015
CABLE ASSY, MRM/OPTION MODULE 9500-0072
MODULE INTERFACE PCB ASSY 9301-0106
MODULE PORT PCB ASSY 9301-0036
INDUCTOR COIL 9140-0050
PATIENT RELAY 9175-0020
BATTERY PACK 1004-0009
BATTERY HARNESS 9500-0203
MEDICAL REPORT MODULE (MRM) 1006-0002
AAMI ECG CABLE ASSY 9500-0229
ECG CONNECTOR ASSY 9500-0065
TO BRACKET
JUMPER CABLE 9500-0231
MULTIFUNCTION CABEL ASSY 1006-0048
MULTIFUNCTION RECEPTACLE ASSY 9500-0232
PATIENT CONNECTOR PANEL ASSY 1006-0012

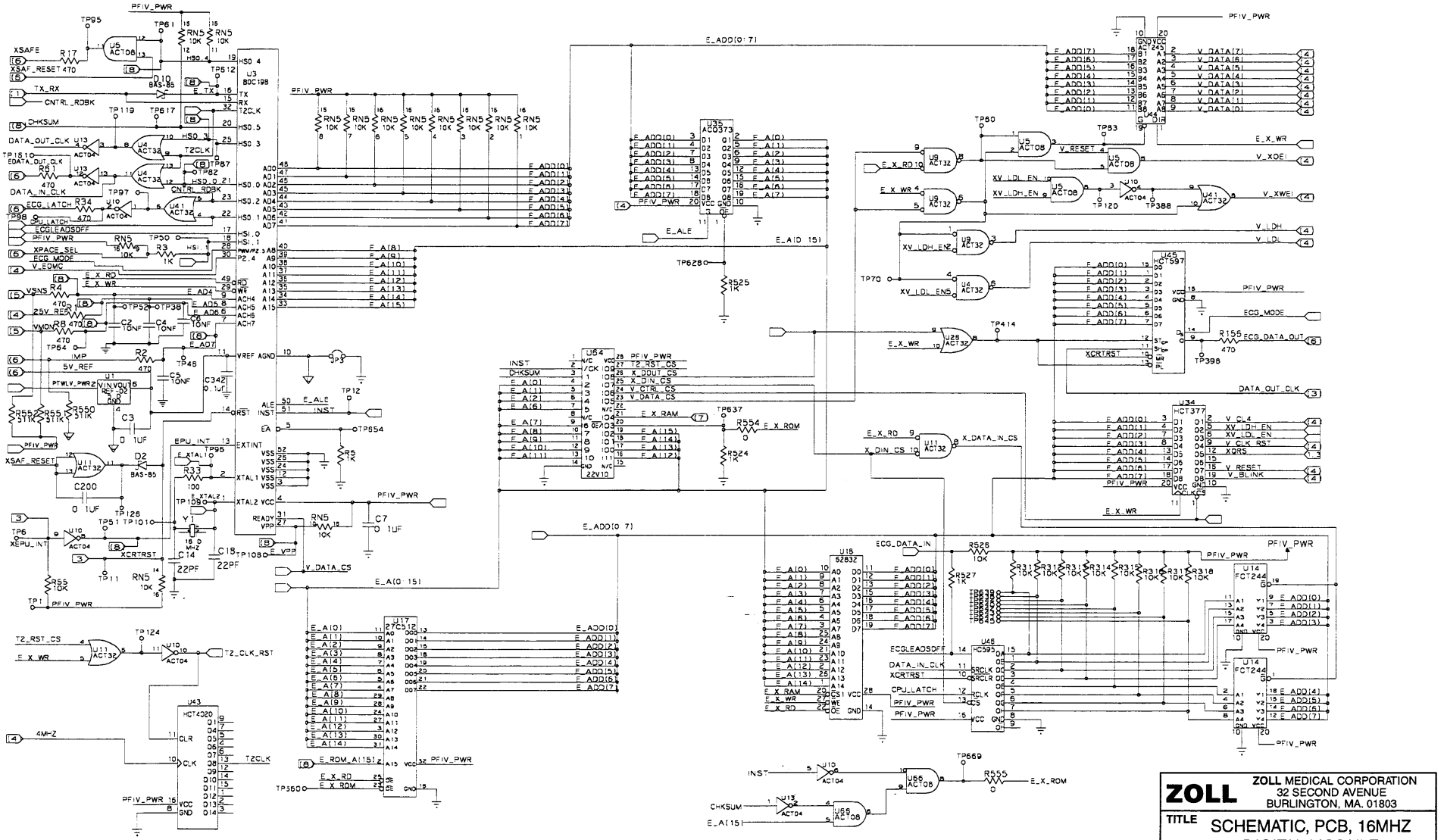
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	INTERCONNECT DIAGRAM
SHT 1 OF 1	SCALE NONE



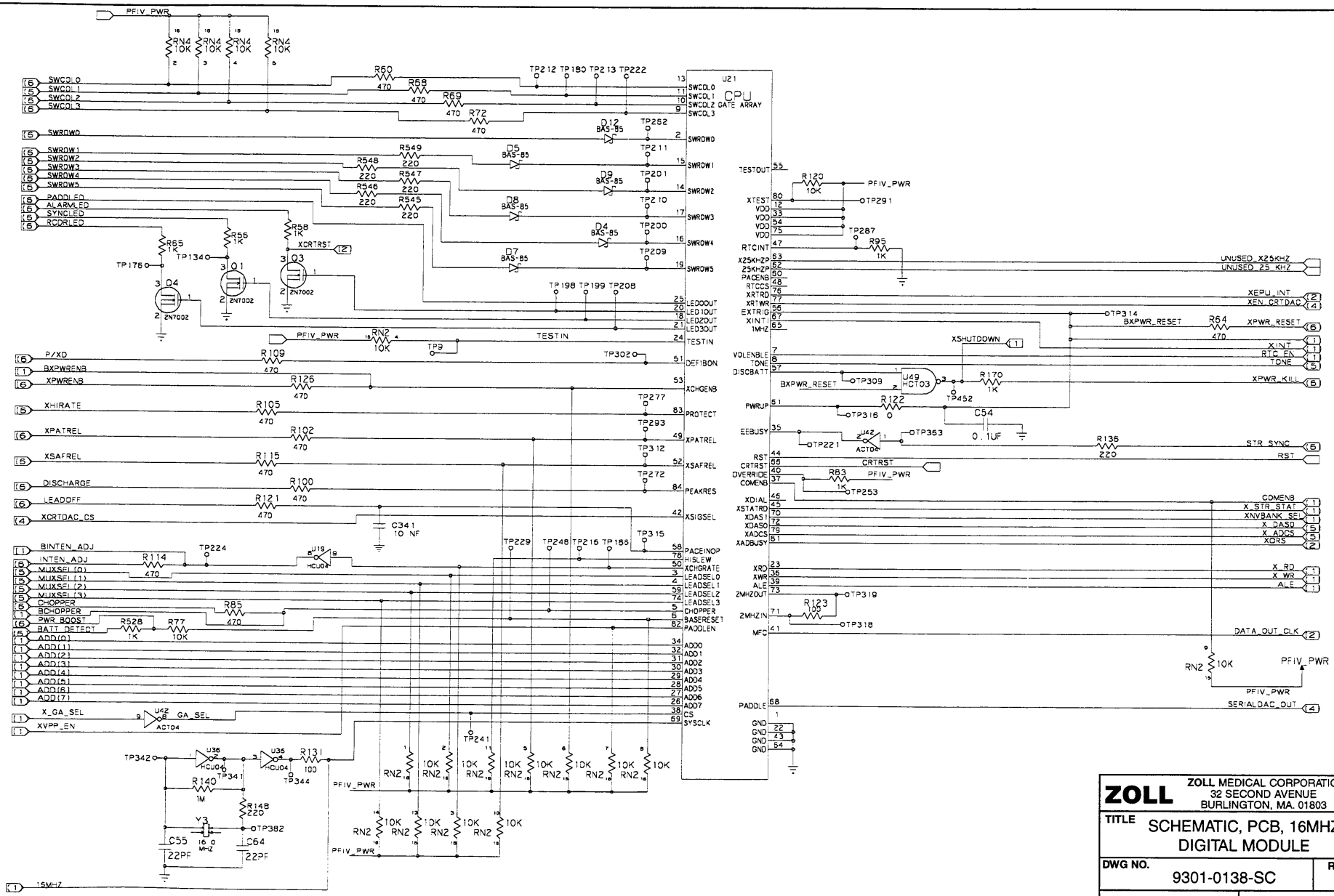
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, POWER SUPPLY, 1600
DWG NO.	9301-0062-SC
REV.	A
SHT 1 OF 1	SCALE NONE



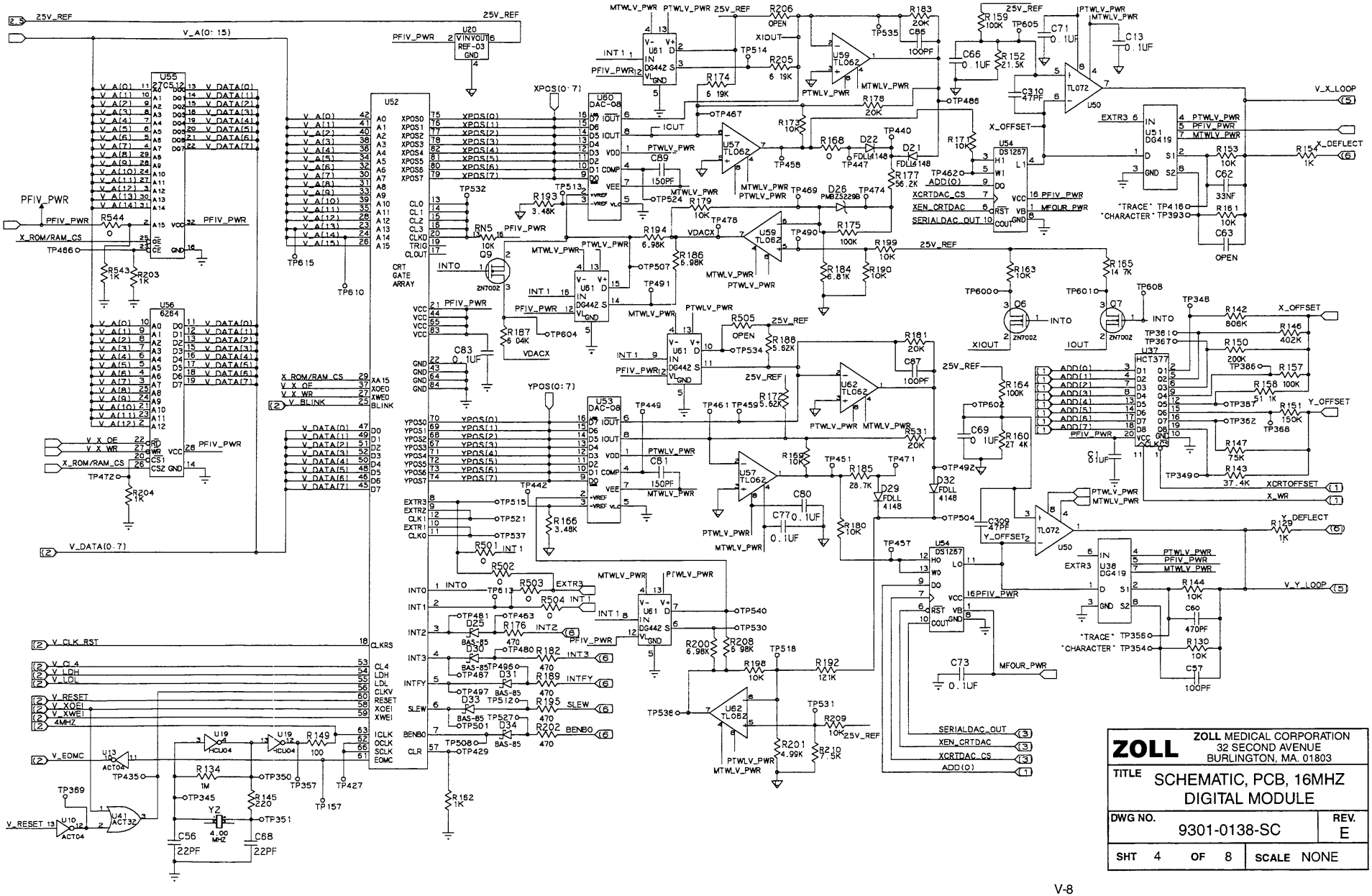
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE
DWG NO.	9301-0138-SC
REV.	E
SHT	1 OF 8
SCALE	NONE



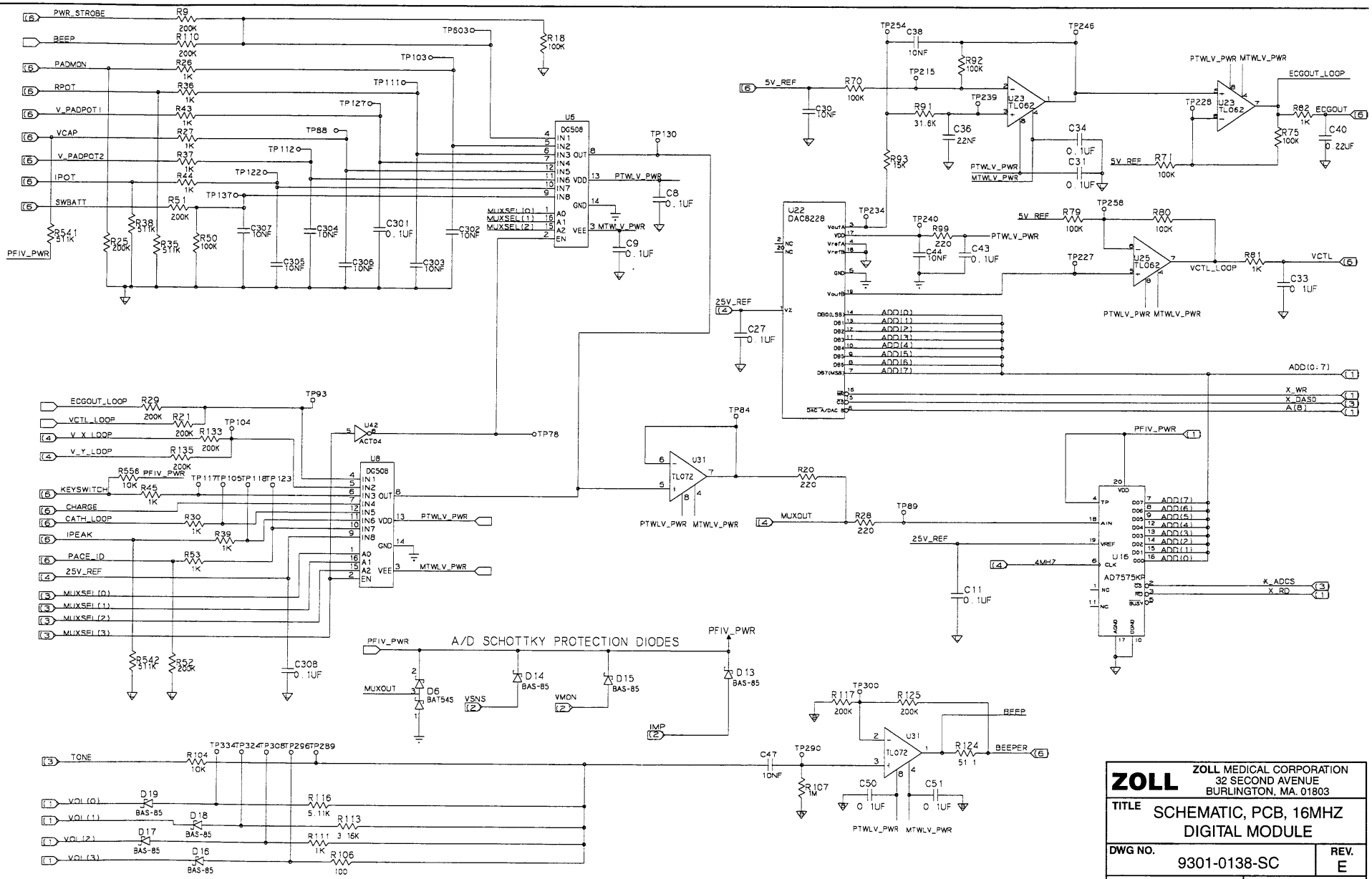
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE
DWG NO. 9301-0138-SC	REV. E
SHT 2 OF 8	SCALE NONE



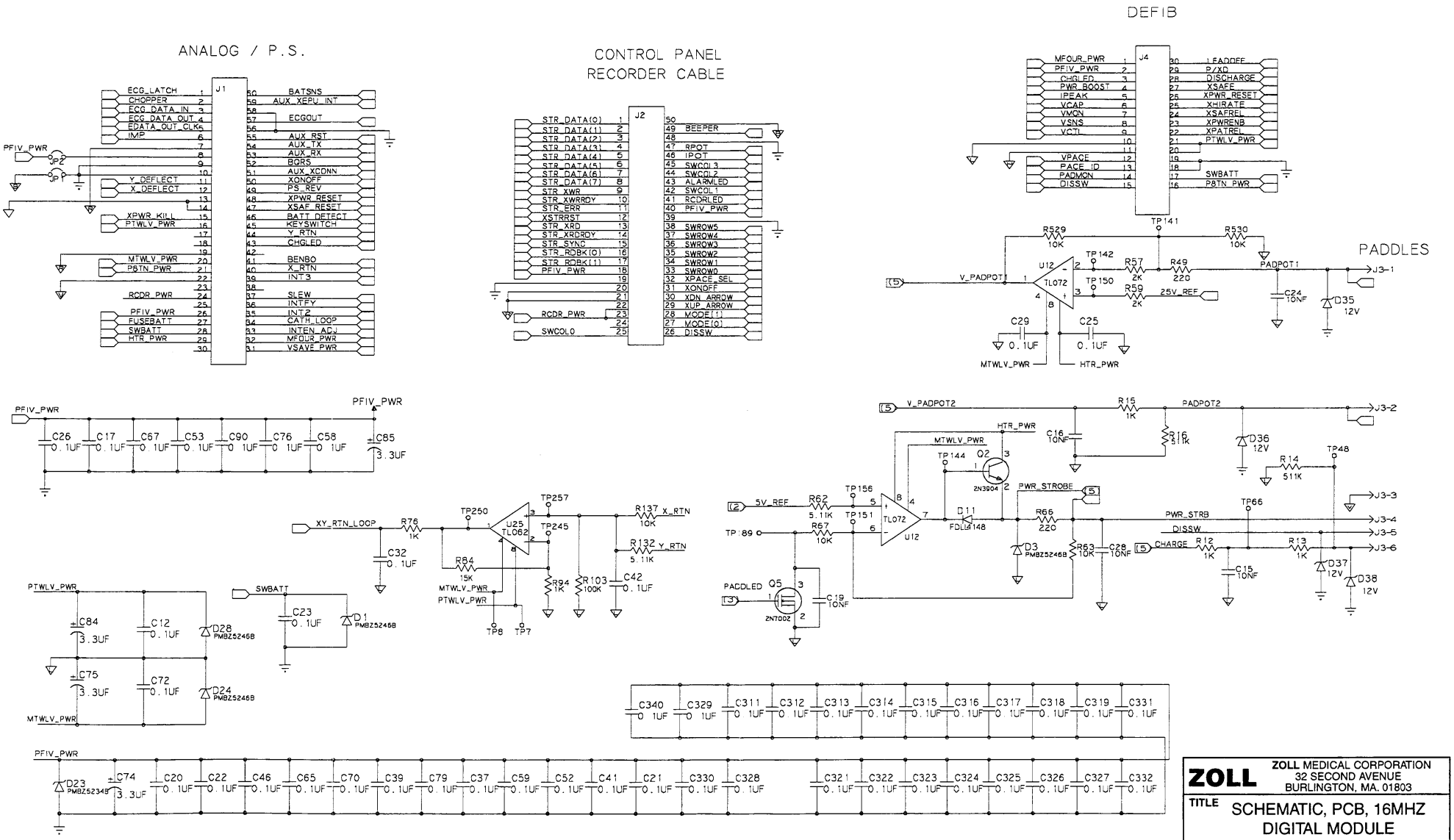
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE
DWG NO.	9301-0138-SC
REV.	E
SHT 3 OF 8	SCALE NONE



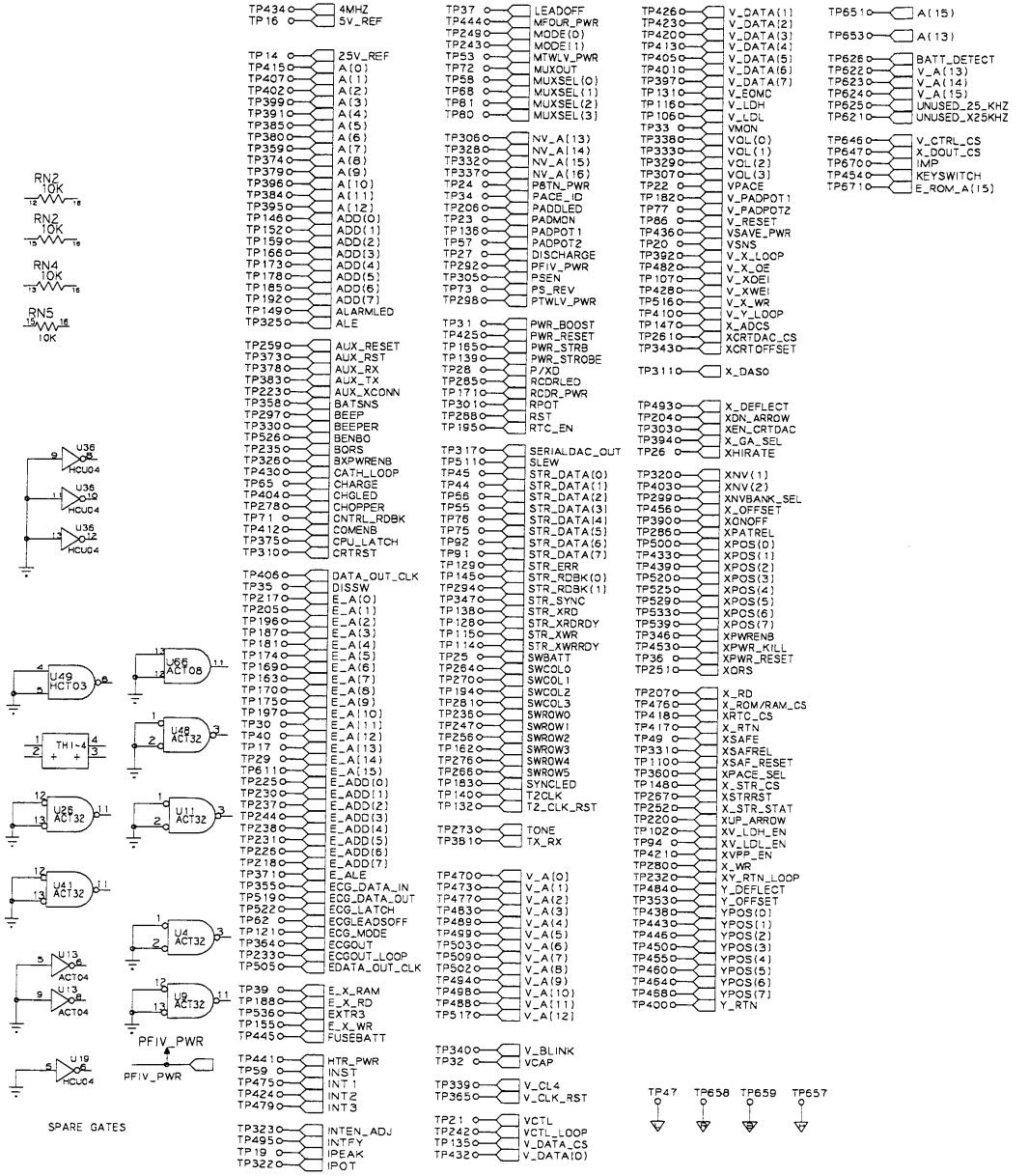
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE
DWG NO.	9301-0138-SC
REV.	E
SHT 4 OF 8	SCALE NONE



ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE
DWG NO.	9301-0138-SC
REV.	E
SHT 5	OF 8
SCALE	NONE



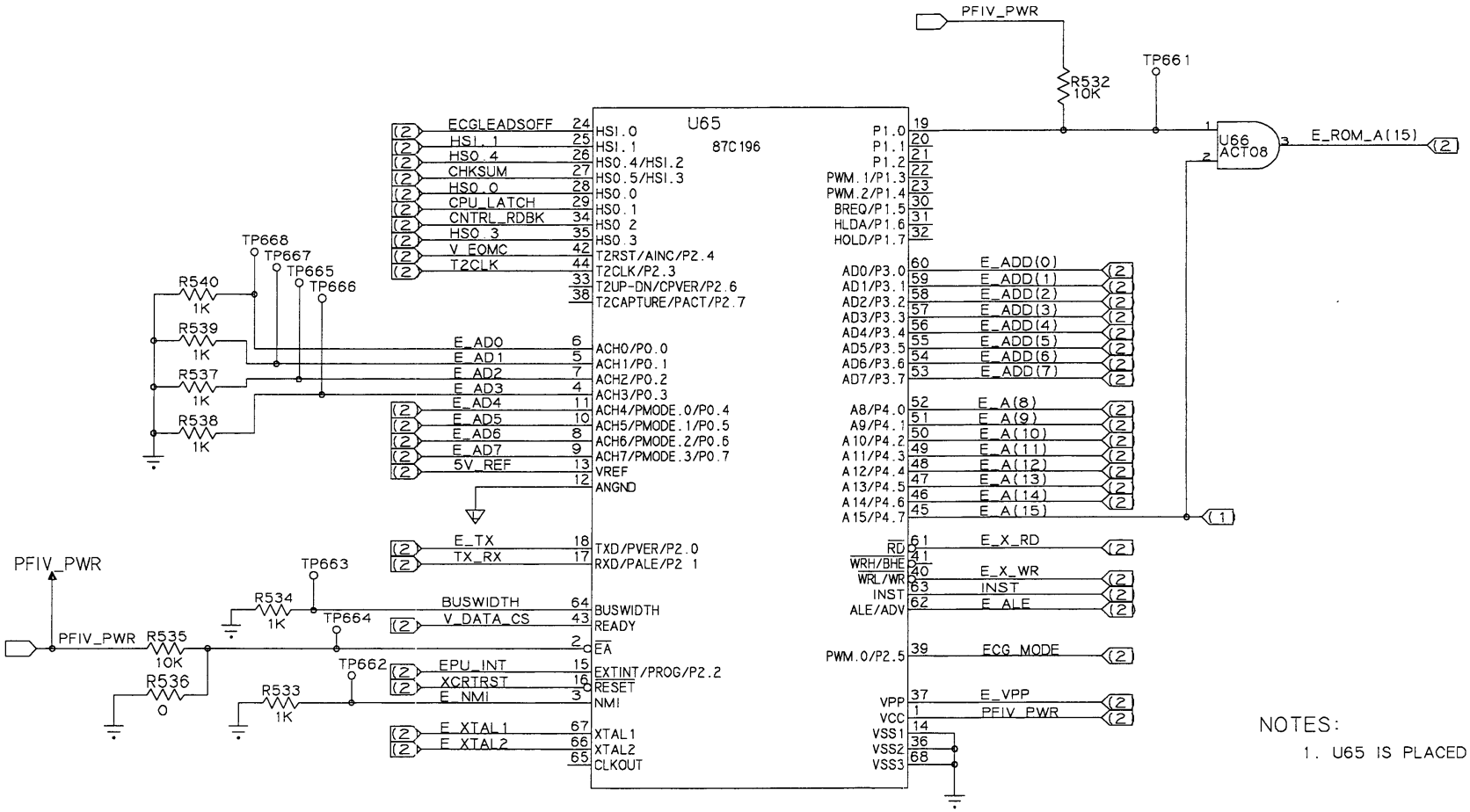
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE	
DWG NO.	9301-0138-SC	REV. E
SHT 6 OF 8	SCALE NONE	



LAST USED REFERENCE DESIGNATORS

INTEGRATED CIRCUIT	U66
DIODE	D38
CAPACITOR	C342
RESISTOR	R556
TRANSISTOR	Q9
RESISTOR NETWORK	RN5
CRYSTAL	Y5
TEST POINT	TP671

ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE	
DWG NO.	9301-0138-SC	REV. E
SHT 7 OF 8	SCALE NONE	

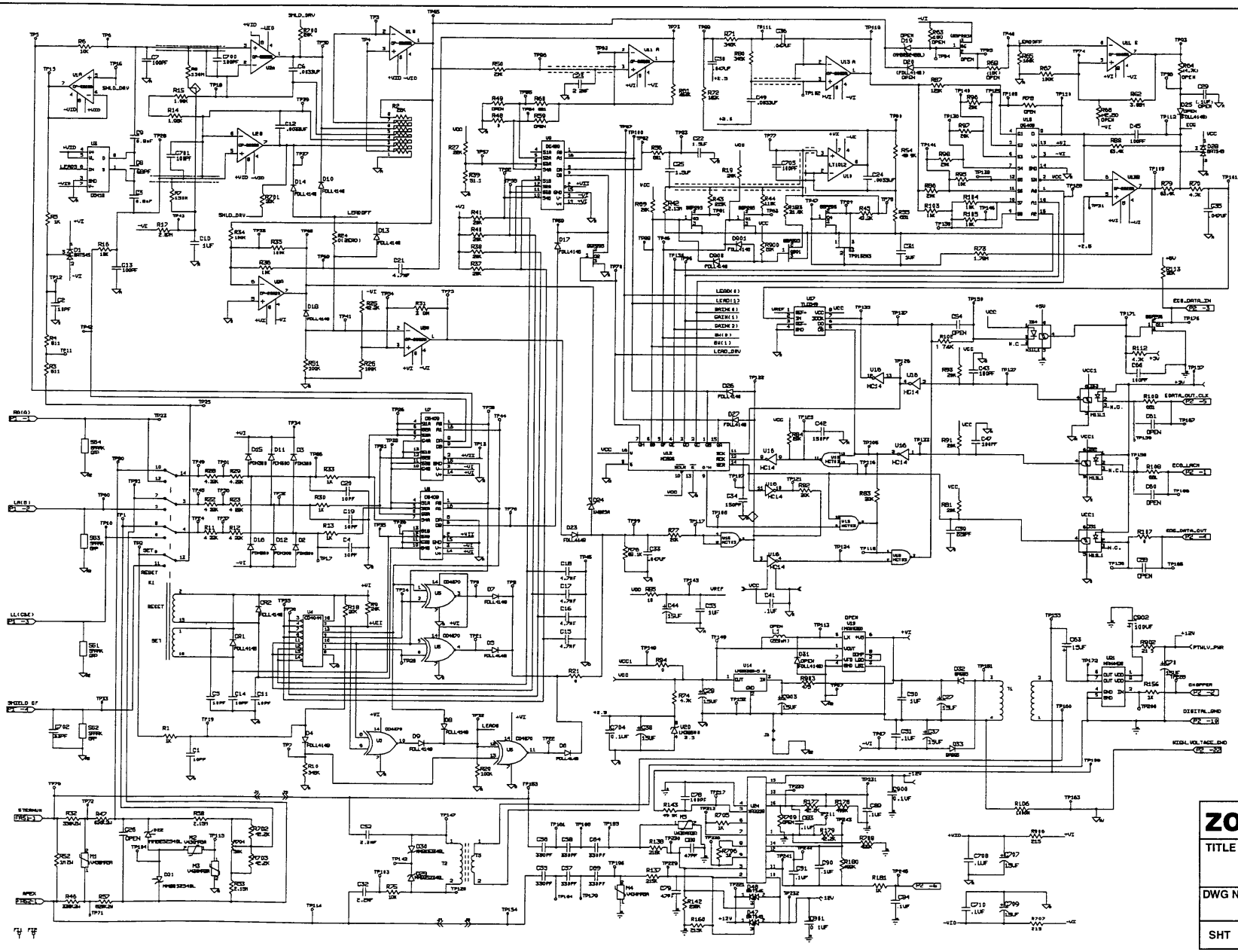


NOTES:

1. U65 IS PLACED ON 9301-0138-02 BOARDS ONLY.

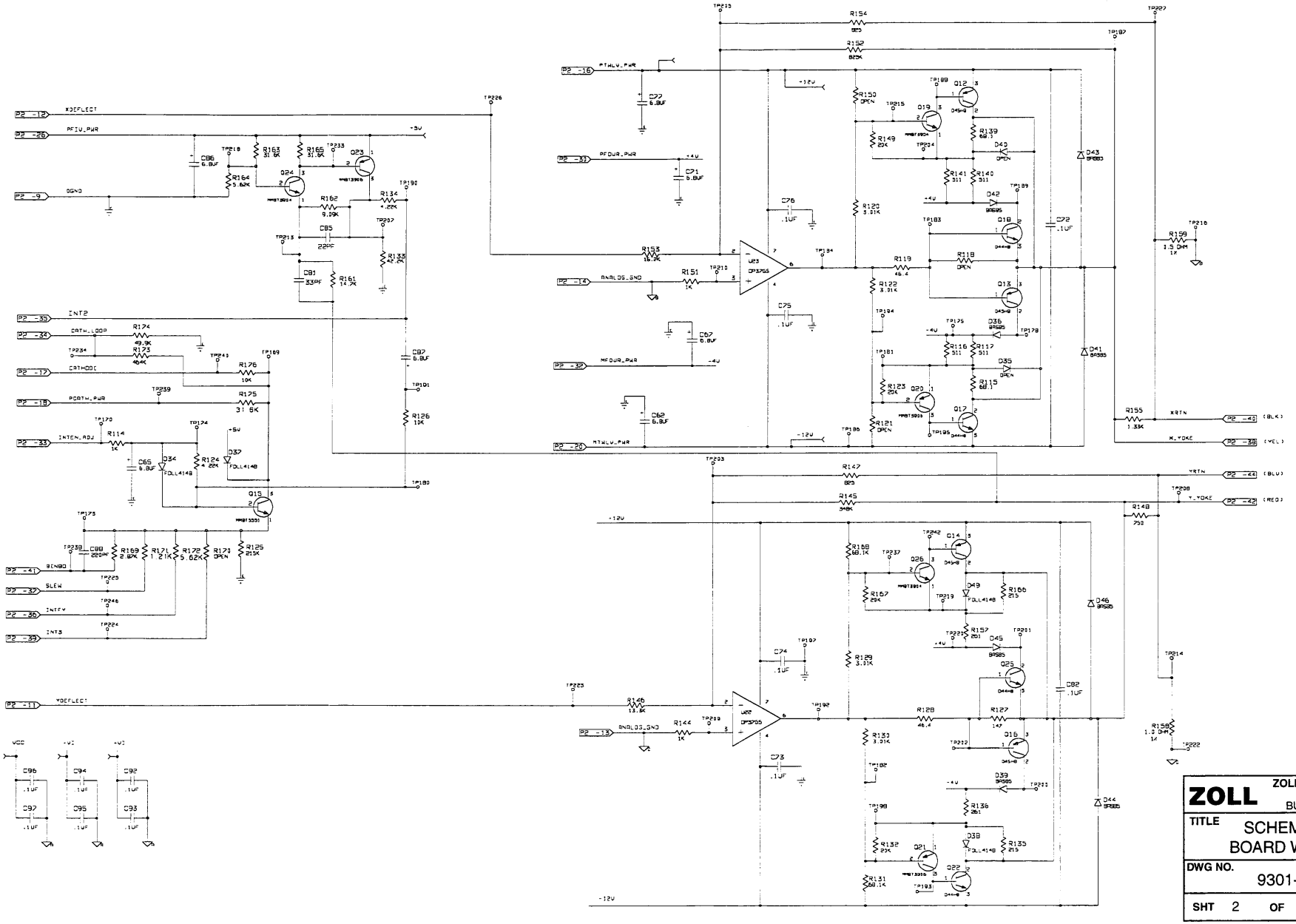
NOTE: U65 IS INSTALLED ON THE 9301-0138-02 ASSEMBLY.
U3 IS INSTALLED ON THE 9301-0138-01 ASSEMBLY.

ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, 16MHZ DIGITAL MODULE
DWG NO. 9301-0138-SC	REV. E
SHT 8 OF 8	SCALE NONE

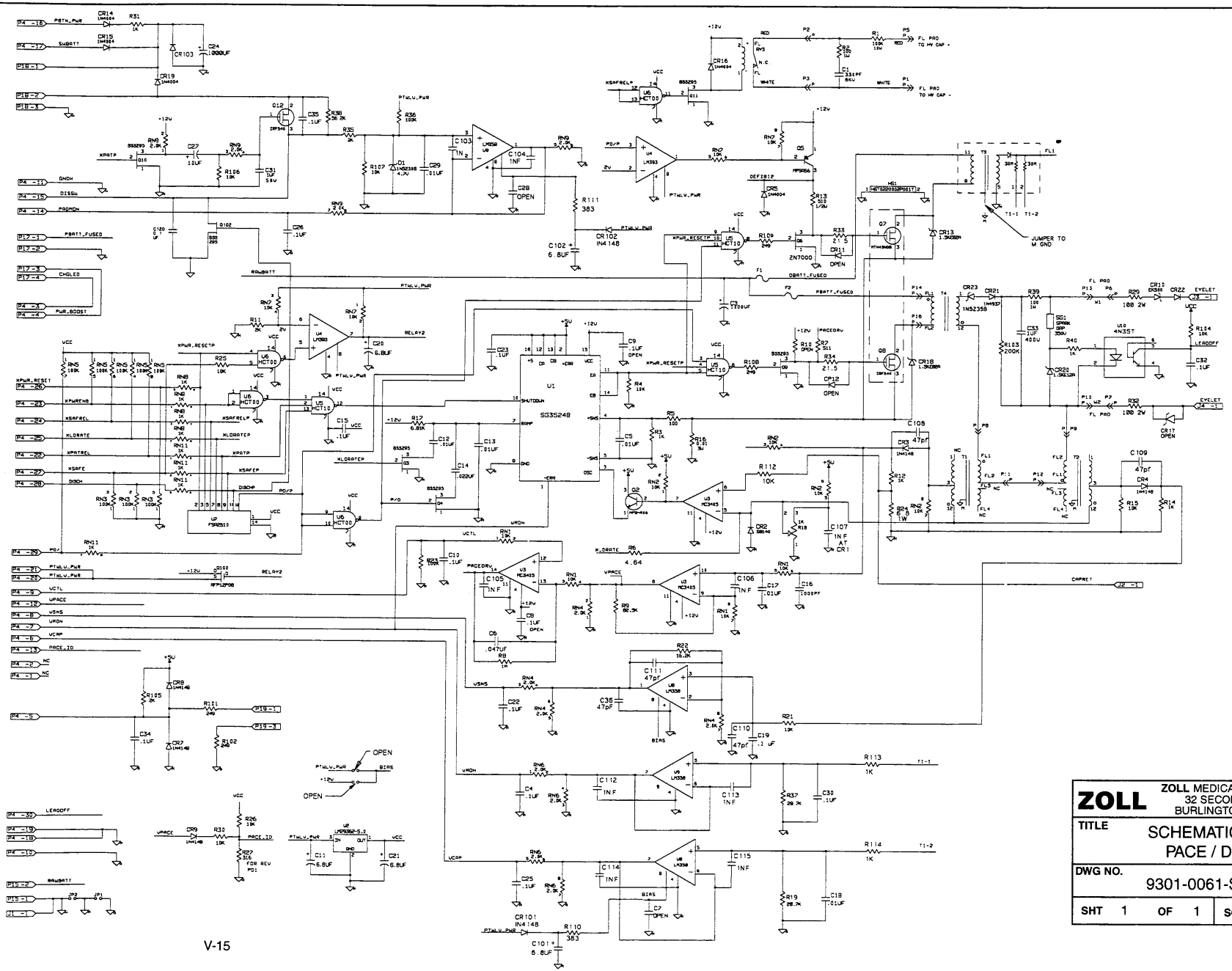


DESIGNATION NUMBERS	
NOT USED	LAST USED
R89, R90, R92, R99-R101, R110, R111 R182, R184-R699, R710-R899, R901, R904, R905	R906
C40, C45, C48, C68, C96-C699, C703, C706, C711-C899.	C903
D50-D899	D901
Q7-Q10, Q27-Q900	Q901
TP123, TP131, TP132, TP134, TP144, TP145, TP162, TP177.	TP246

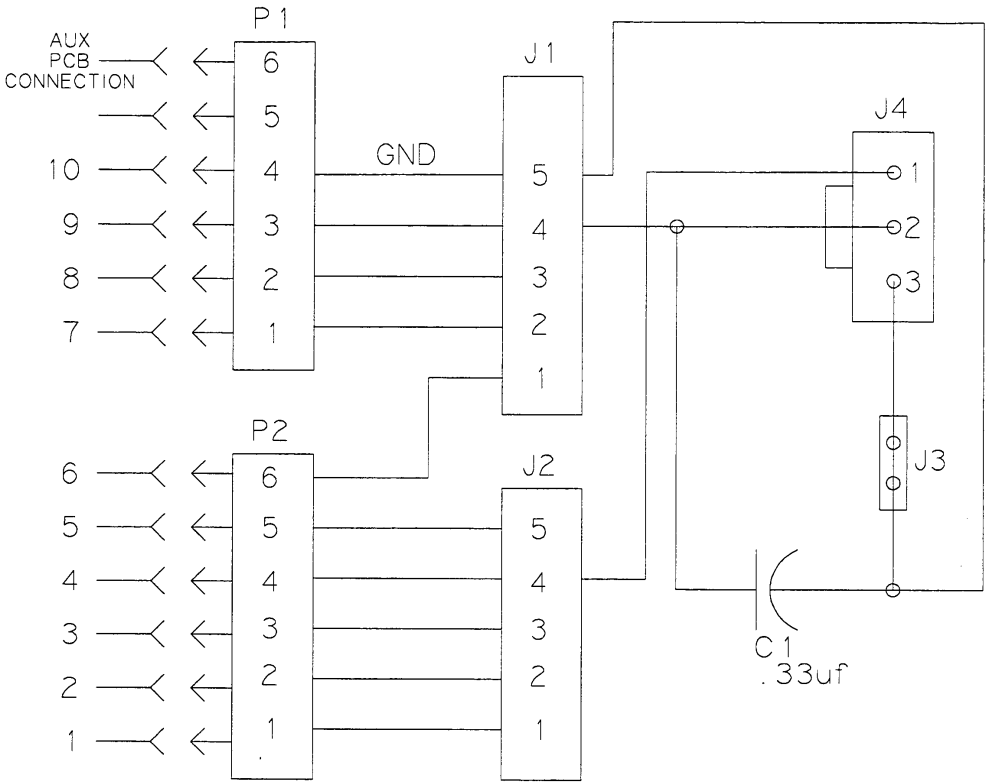
ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	SCHEMATIC, ANALOG BOARD, WITH IMPEDANCE	
DWG NO.	9301-0136-SC	REV. E
SHT 1 OF 2	SCALE NONE	



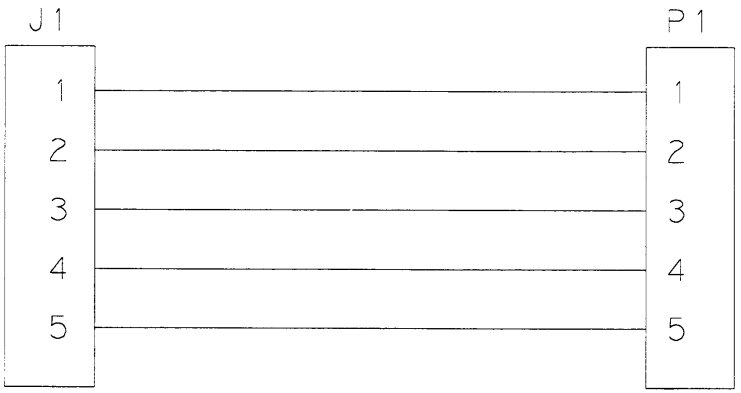
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	SCHEMATIC, ANALOG BOARD WITH IMPEDANCE	
DWG NO.	9301-0136-SC	REV. E
SHT 2 OF 2	SCALE NONE	



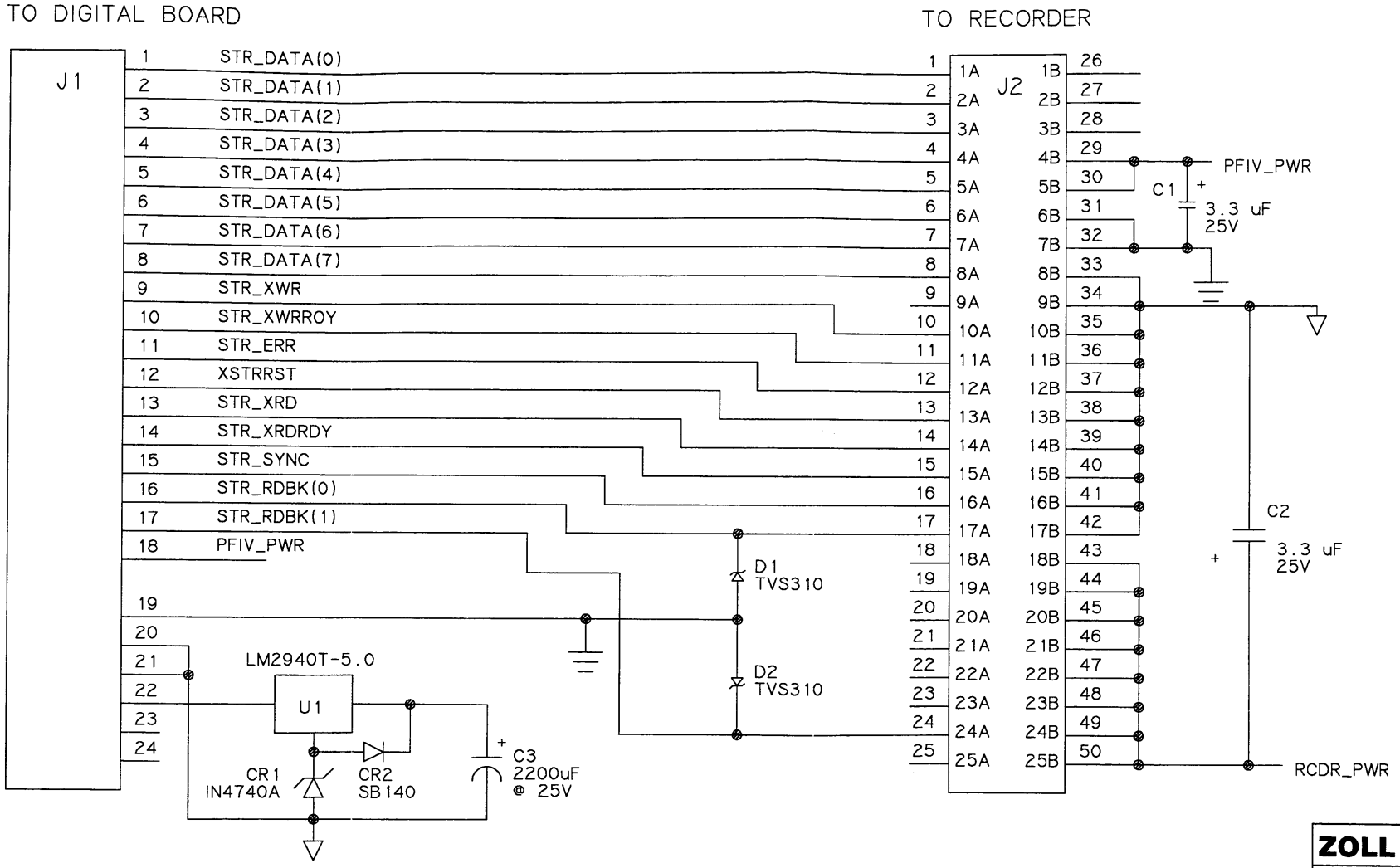
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, PACE / DEFIB
DWG NO.	9301-0061-SC
REV.	A
SHT 1 OF 1	SCALE NONE



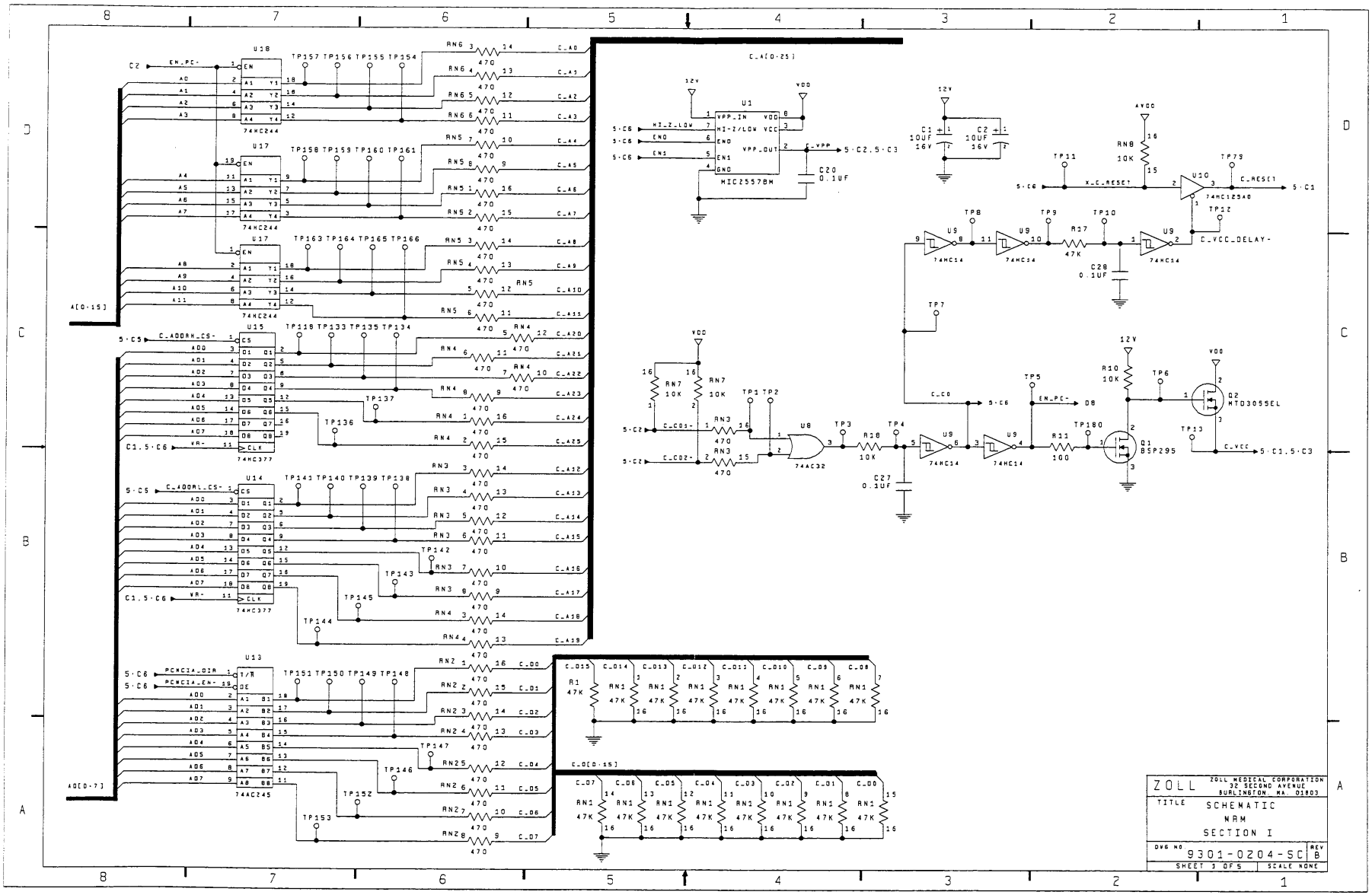
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	SCHEMATIC, PCB, MODULE PORT	
DWG NO.	9301-0036-SC	REV. A
SHT 1 OF 1	SCALE NONE	

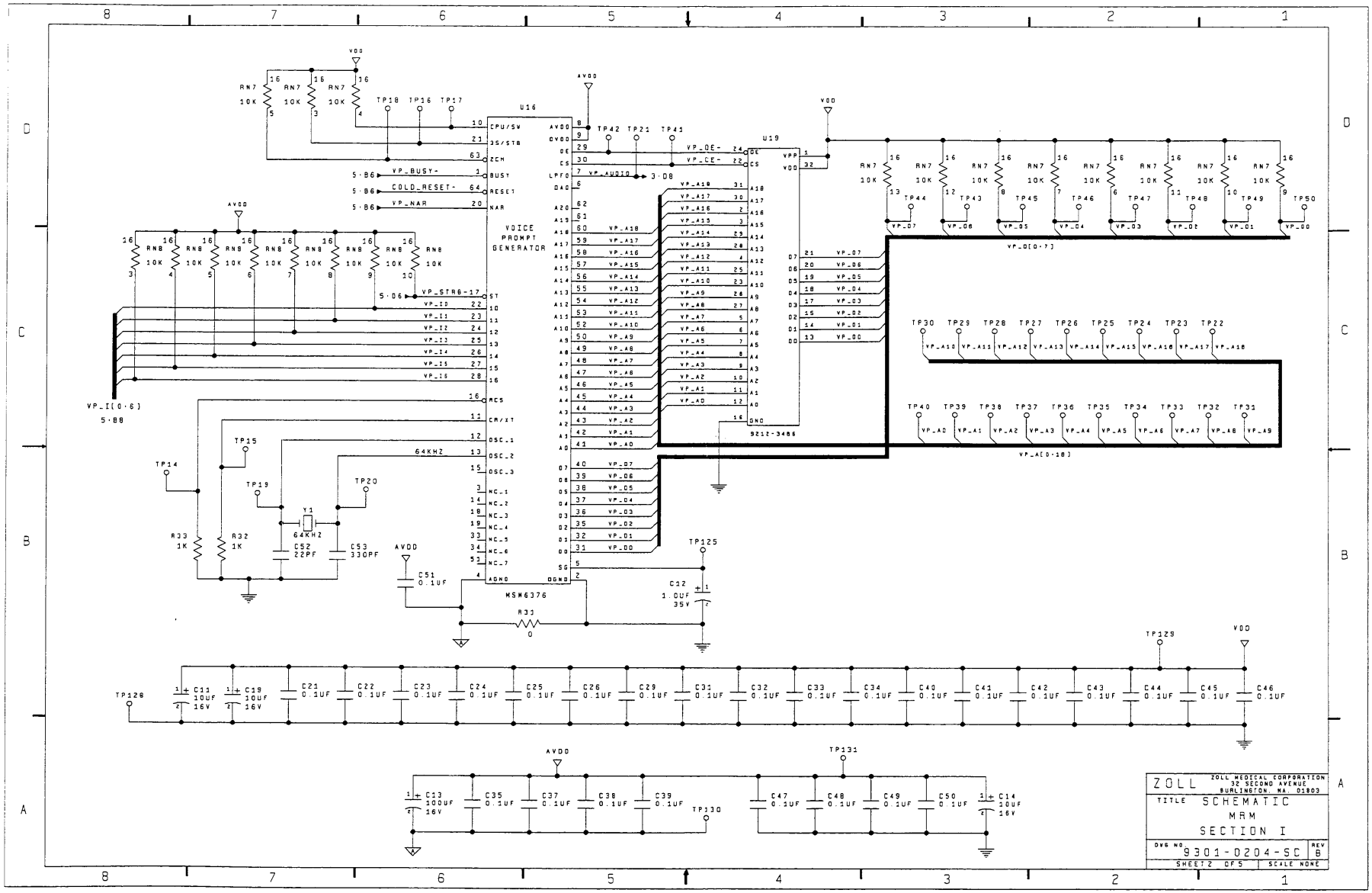


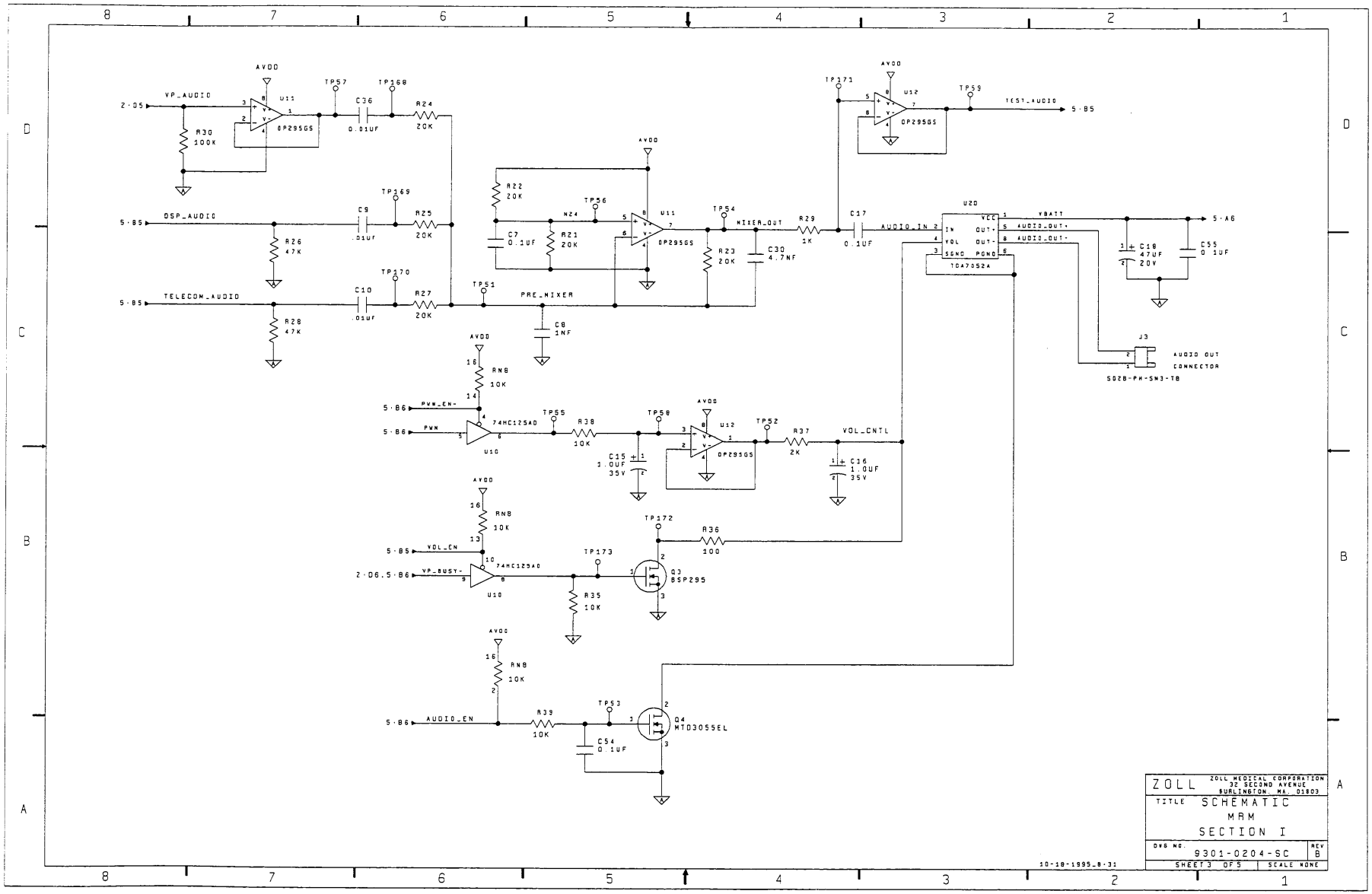
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	SCHEMATIC, PCB, CHARGER PORT	
DWG NO.	9301-0027-SC	REV. A
SHT 1 OF 1	SCALE NONE	

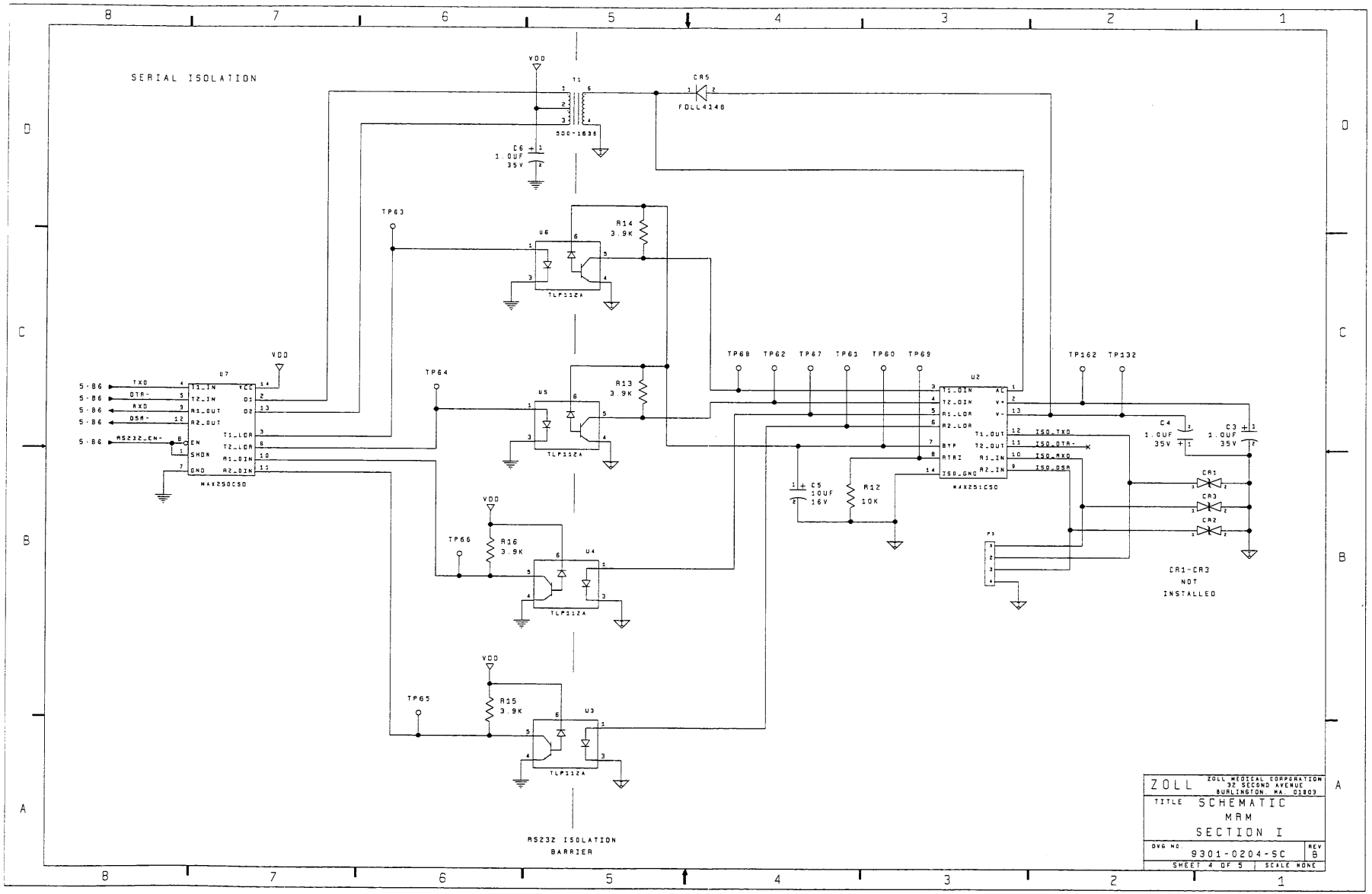


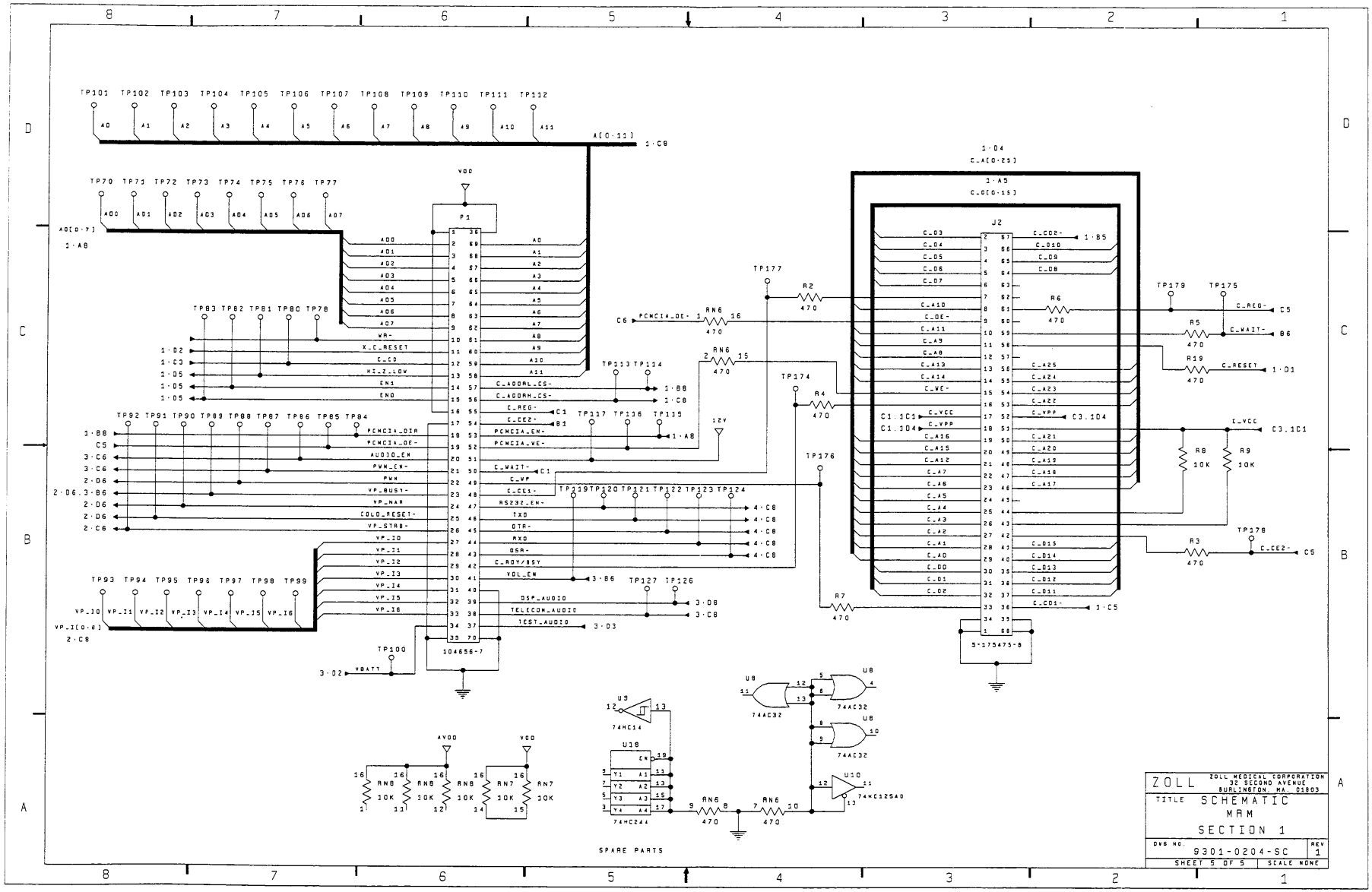
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, RECORDER INTERFACE
DWG NO.	9301-0107-SC
REV.	A
SHT 1 OF 1	SCALE NONE

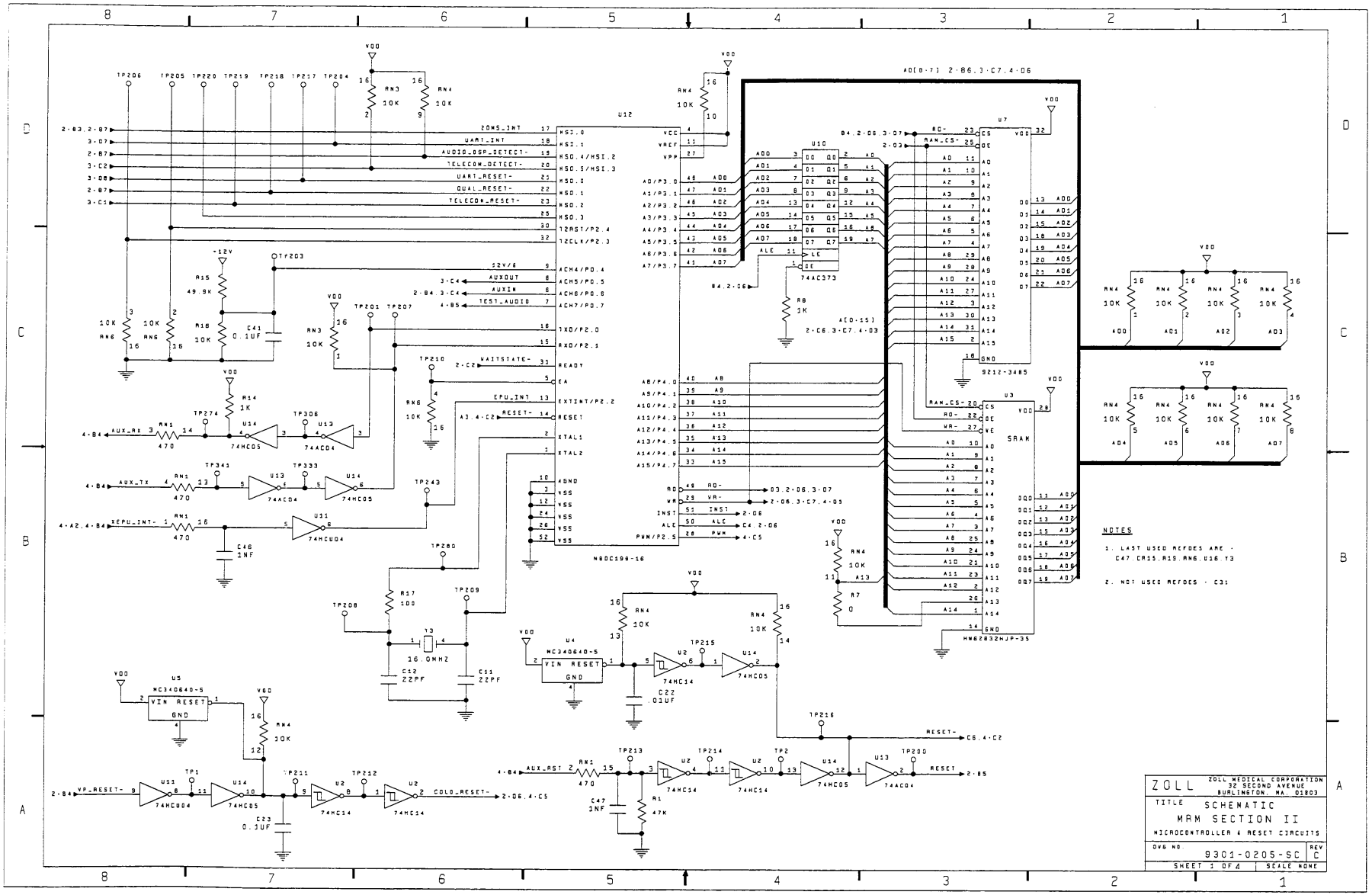

ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE
SCHEMATIC
NRM
SECTION I
DWG NO 9301-0204-SC
REV B
SHEET 3 OF 5
SCALE NONE

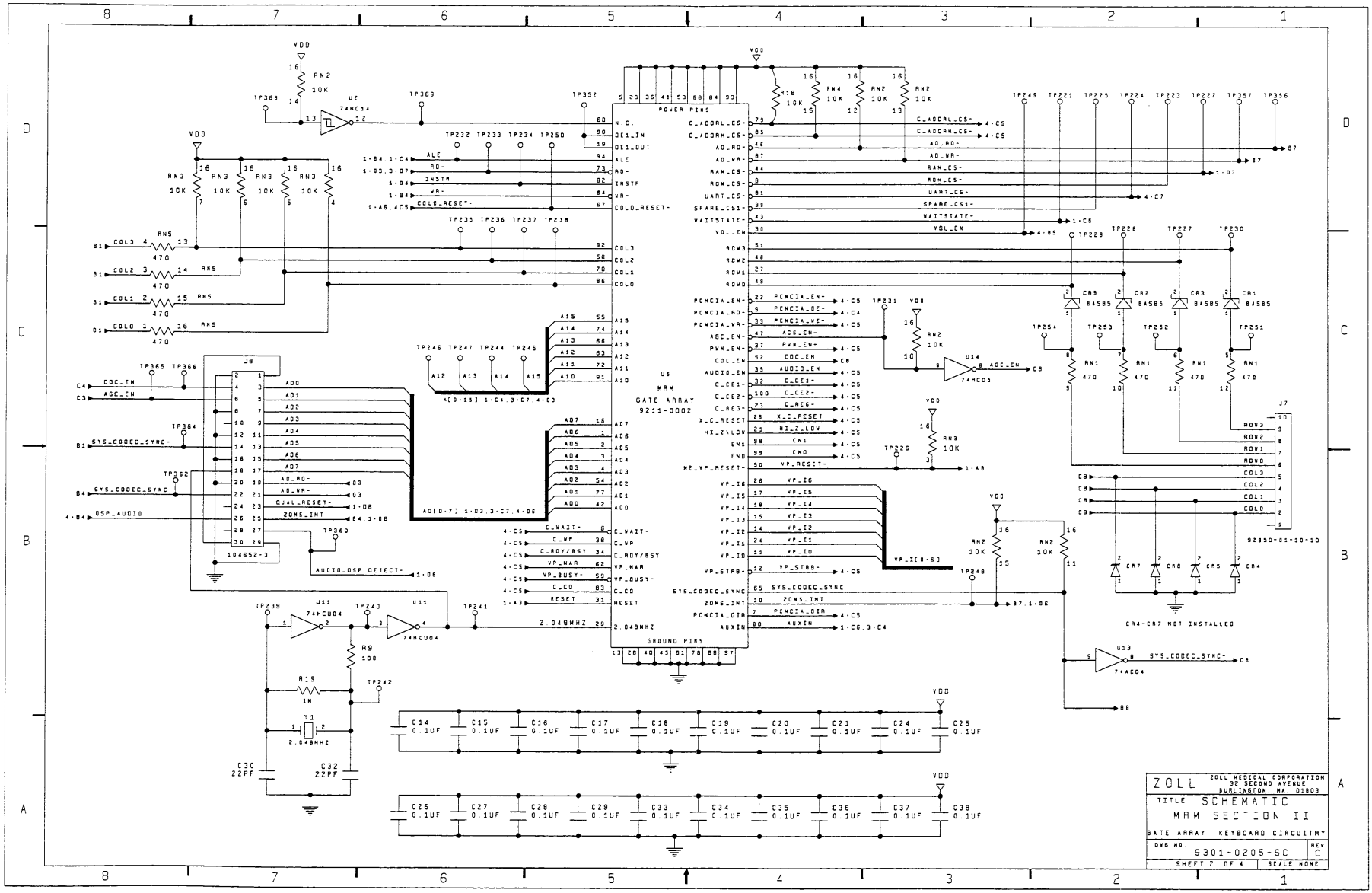

U16
VOICE PROMPT GENERATOR
MSM6376
U19
9212-3486
64KHZ
VP_I[0:6]
VP_A[0:18]
VP_D[0:7]
ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE SCHEMATIC
MRM
SECTION I
DWG NO 9301-0204-SC
REV B
SHEET 2 OF 5
SCALE NONE

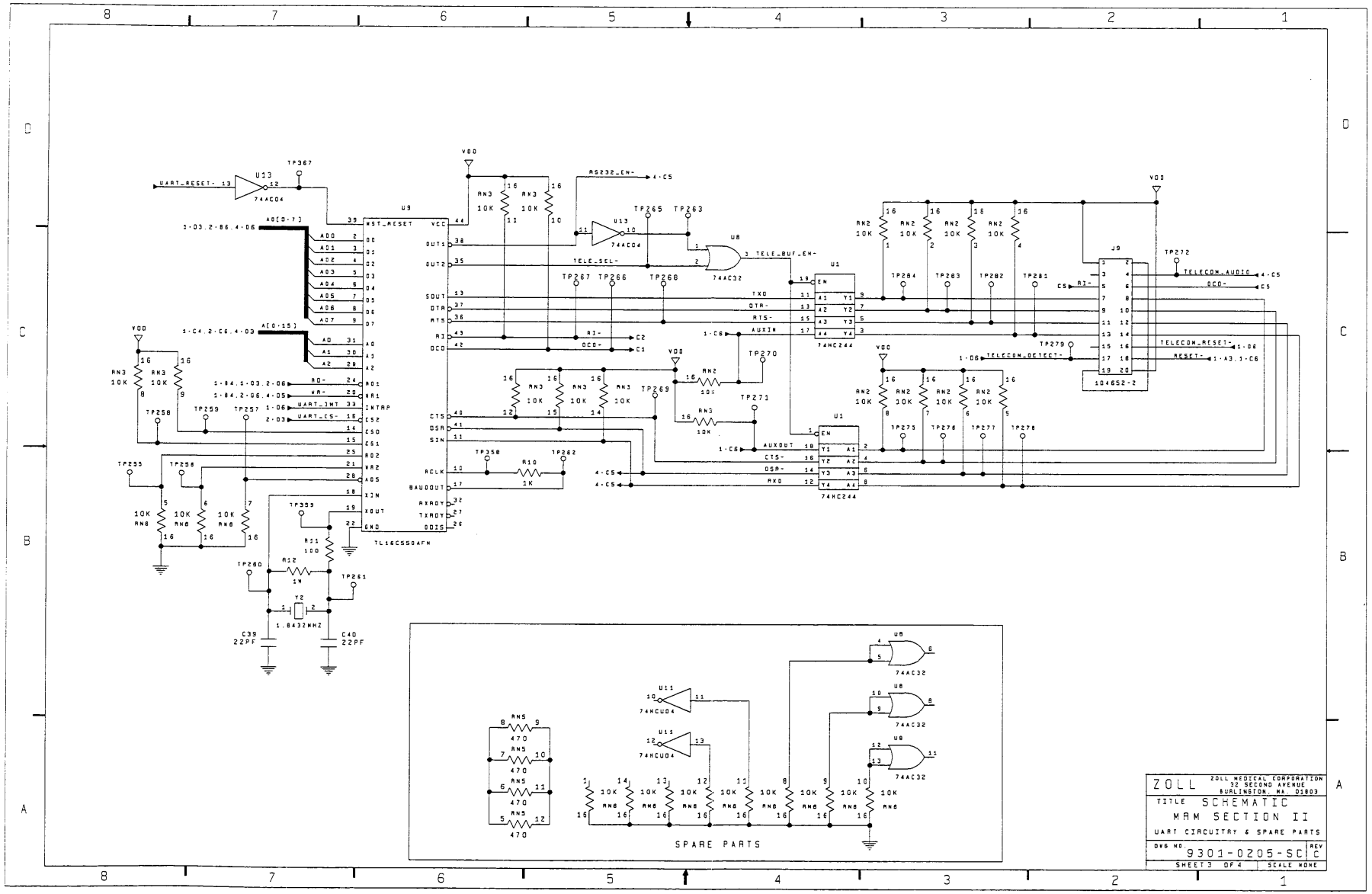

AVDD
VP_AUDIO
Z-05
R30 100K
U11
OP295GS
TP57
TP168
C36 0.01UF
R24 20K
TP171
U12
TP59
TEST_AUDIO
5-B5
DSP_AUDIO
5-B5
TP169
C9 .01UF
R25 20K
R26 47K
R22 20K
TP56
N24
C7 0.1UF
R21 20K
TP54
MIXER_OUT
R29 1K
C17 0.1UF
AUDIO_IN
R23 20K
C30 4.7NF
U20
TDA7052A
VCC
IN
VOL
SGND
OUT+
OUT-
PGND
VBATT
AUDIO_OUT+
AUDIO_OUT-
C18 47UF 20V
C55 0.1UF
5-A6
J3
AUDIO OUT CONNECTOR
S02B-PH-SM3-TB
TELECOM_AUDIO
5-B5
TP170
C10 .01UF
R27 20K
R28 47K
TP51
PRE_MIXER
C8 1NF
RN8 10K
PWM_EN-
5-B6
PWM
5-B6
74HC125A0
U10
TP55
R38 10K
TP58
U12
TP52
R37 2K
VOL_CNTL
C15 1.0UF 35V
C16 1.0UF 35V
VOL_EN
5-B5
VP_BUSY-
Z-06,5-B6
TP172
R36 100
TP173
Q3 BSP295
R35 10K
AUDIO_EN
5-B6
R39 10K
TP53
Q4 MTD3055EL
C54 0.1UF
ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE SCHEMATIC
MRM
SECTION I
DWG NO. 9301-0204-SC
REV B
SHEET 3 OF 5
SCALE NONE
10-18-1995_8:31

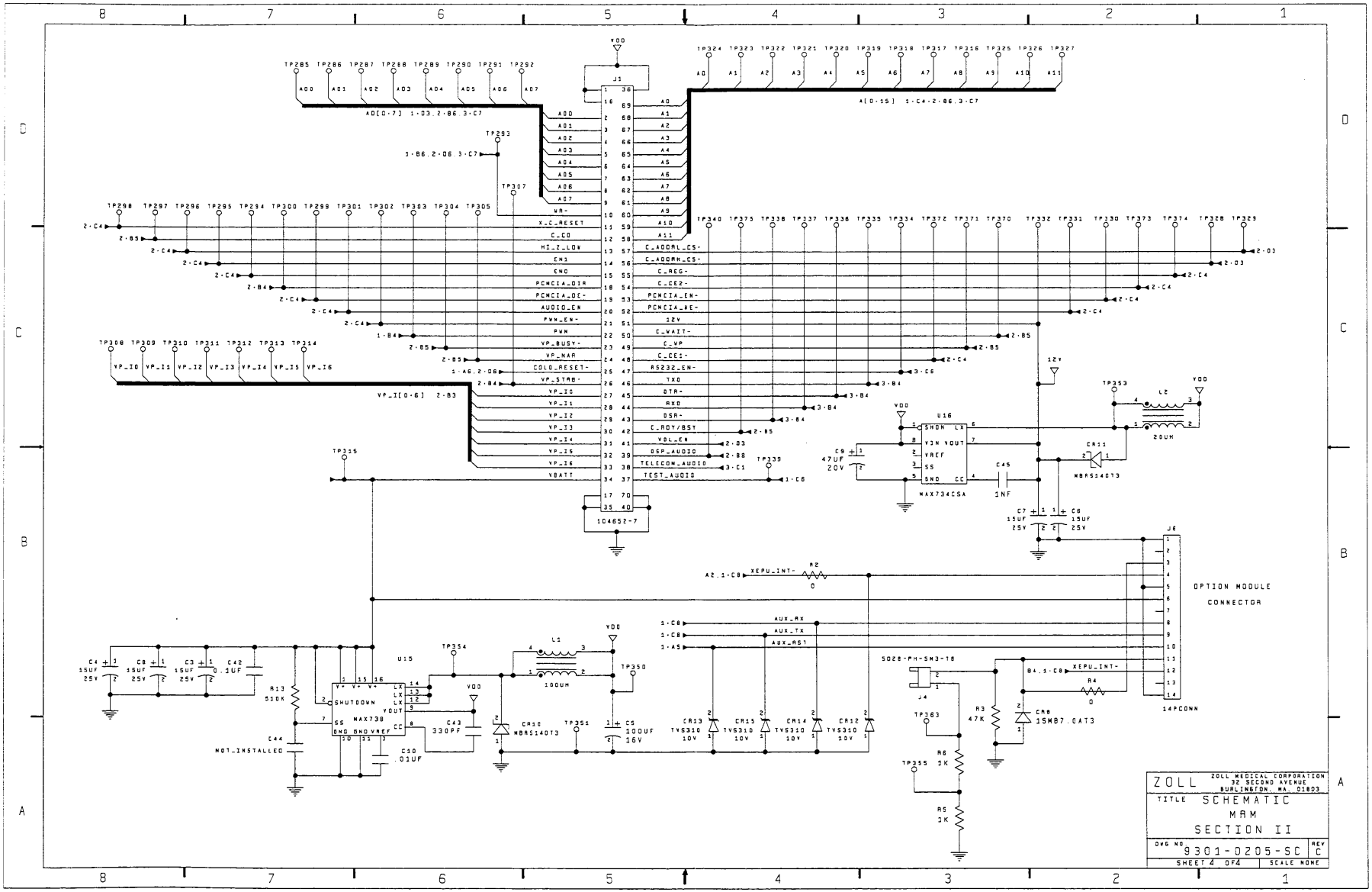

SERIAL ISOLATION
VDD
T1
CR5
FDLL4148
300-1636
C6
1.0UF
35V
TP63
U6
R14
3.9K
TLP112A
TP64
U5
R13
3.9K
TLP112A
TP66
U4
R16
3.9K
TLP112A
TP65
U3
R15
3.9K
TLP112A
U7
MAX250CSD
TXD
DTR-
RXD
DSR-
RS232_EN-
T1_IN
T2_IN
R1_OUT
R2_OUT
T1_LDR
T2_LDR
R1_DIN
R2_DIN
EN
SHDN
GND
VCC
O1
O2
TP68
TP62
TP67
TP61
TP60
TP69
U2
MAX251CSD
C5
10UF
16V
R12
10K
TP162
TP132
C4
1.0UF
35V
C3
1.0UF
35V
ISO_TXD
ISO_DTR-
ISO_RXD
ISO_DSR
CR1
CR3
CR2
CR1-CR3
NOT
INSTALLED
RS232 ISOLATION
BARRIER
ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON MA. 01803
TITLE SCHEMATIC
MAM
SECTION I
DWG NO 9301-0204-SC
REV B
SHEET 4 OF 5
SCALE NONE

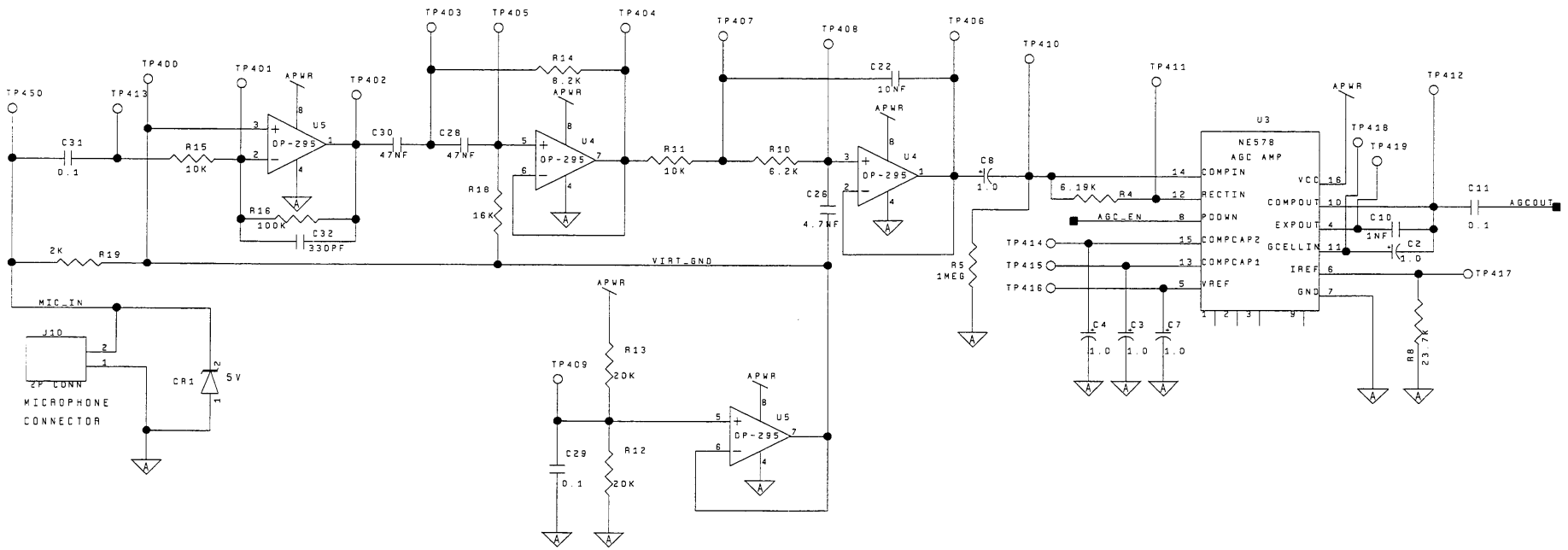

ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE SCHEMATIC
MAM
SECTION 1
DWG NO. 9301-0204-SC
REV 1
SHEET 5 OF 5
SCALE NONE
SPARE PARTS
J2
P1
A[0:11]
AD[0:7]
C_A[0:25]
C_D[0:15]
104656-7
5-175475-8
74HC14
74HC244
74AC32
74HC125A0
RN6 470
RN7 10K
RN8 10K
R2 470
R4 470
R5 470
R6 470
R7 470
R8 10K
R9 10K
R19 470
R3 470


NOTES
1. LAST USED REFDES ARE : C47 CR15 R19 RN6 U16 Y3
2. NOT USED REFDES - C31
ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE
SCHEMATIC
MAM SECTION II
MICROCONTROLLER & RESET CIRCUITS
DWG NO. 9301-0205-SC
REV C
SHEET 1 OF 4
SCALE NONE

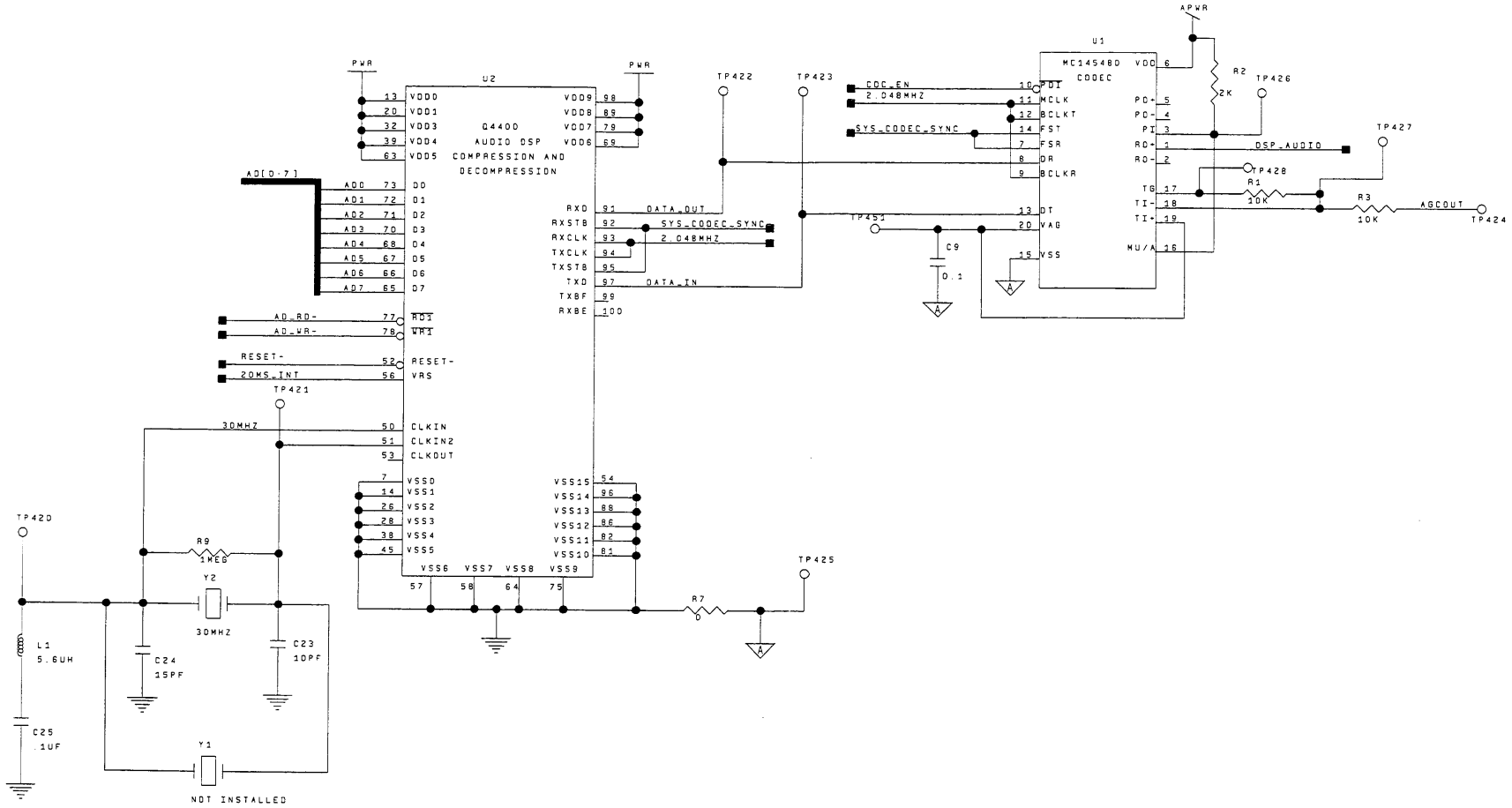

ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE SCHEMATIC
MRM SECTION II
GATE ARRAY KEYBOARD CIRCUITRY
DWG NO 9301-0205-SC
REV C
SHEET 2 OF 4
SCALE NONE
MRM GATE ARRAY 9211-0002
74HC14
74HCU04
74HC05
74AC04
BAS85
CR4-CR7 NOT INSTALLED
92950-01-10-10
104652-3
POWER PINS
GROUND PINS
2.048MHZ
AUDIO_DSP_DETECT-
SYS_CODEC_SYNC
ZOMS_INT
VP_RESET-
VOL_EN
AGC_EN
COC_EN


SPARE PARTS
ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA 01803
TITLE SCHEMATIC
MAM SECTION II
UART CIRCUITRY & SPARE PARTS
DWG NO. 9301-0205-SC
REV C
SHEET 3 OF 4
SCALE NONE

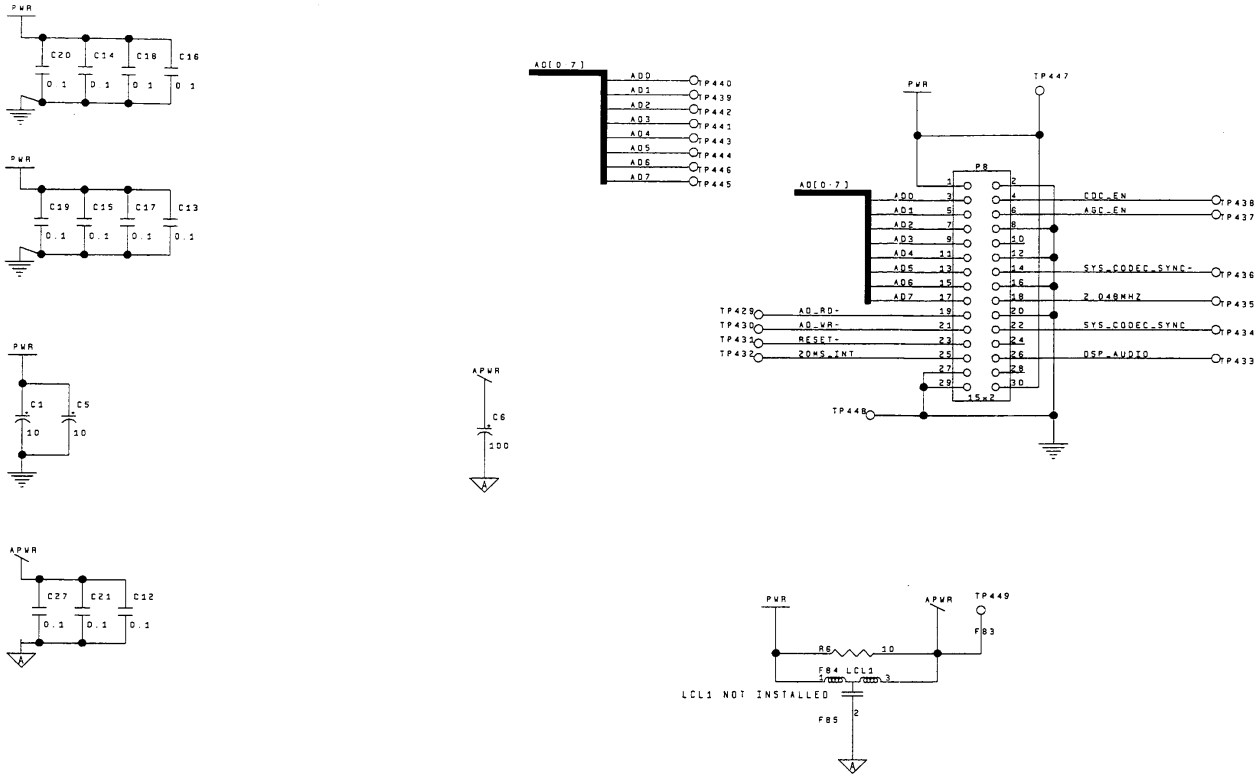

ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE SCHEMATIC
MAM
SECTION II
DWG NO 9301-0205-SC
REV C
SHEET 4 OF4
SCALE NONE
OPTION MODULE CONNECTOR
14PCONN
J1
104652-7
U15
MAX738
U16
MAX734CSA
L1
100UH
L2
20UH
MBRS140T3
1SMB7.0AT3
TVS310 10V
5028-PH-SM3-TB
NOT_INSTALLED



ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	**SCHEMATIC, AUDIO DSP BOARD**
DWG NO. **9301-0206-SC**	REV **A**
SHT **1** OF **3**	SCALE: **NONE**

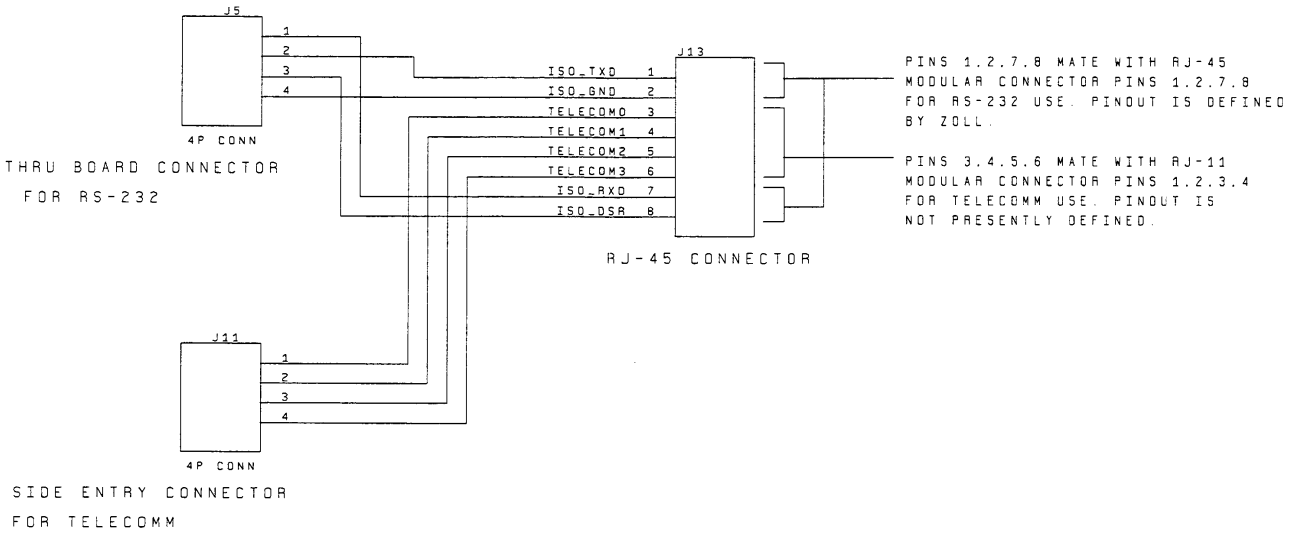


ZOLL	ZOLL MEDICAL COPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	**SCHEMATIC, AUDIO DSP BOARD**
DWG NO. **9301-0206-SC**	REV **A**
SHT **2** OF **3**	SCALE: **NONE**

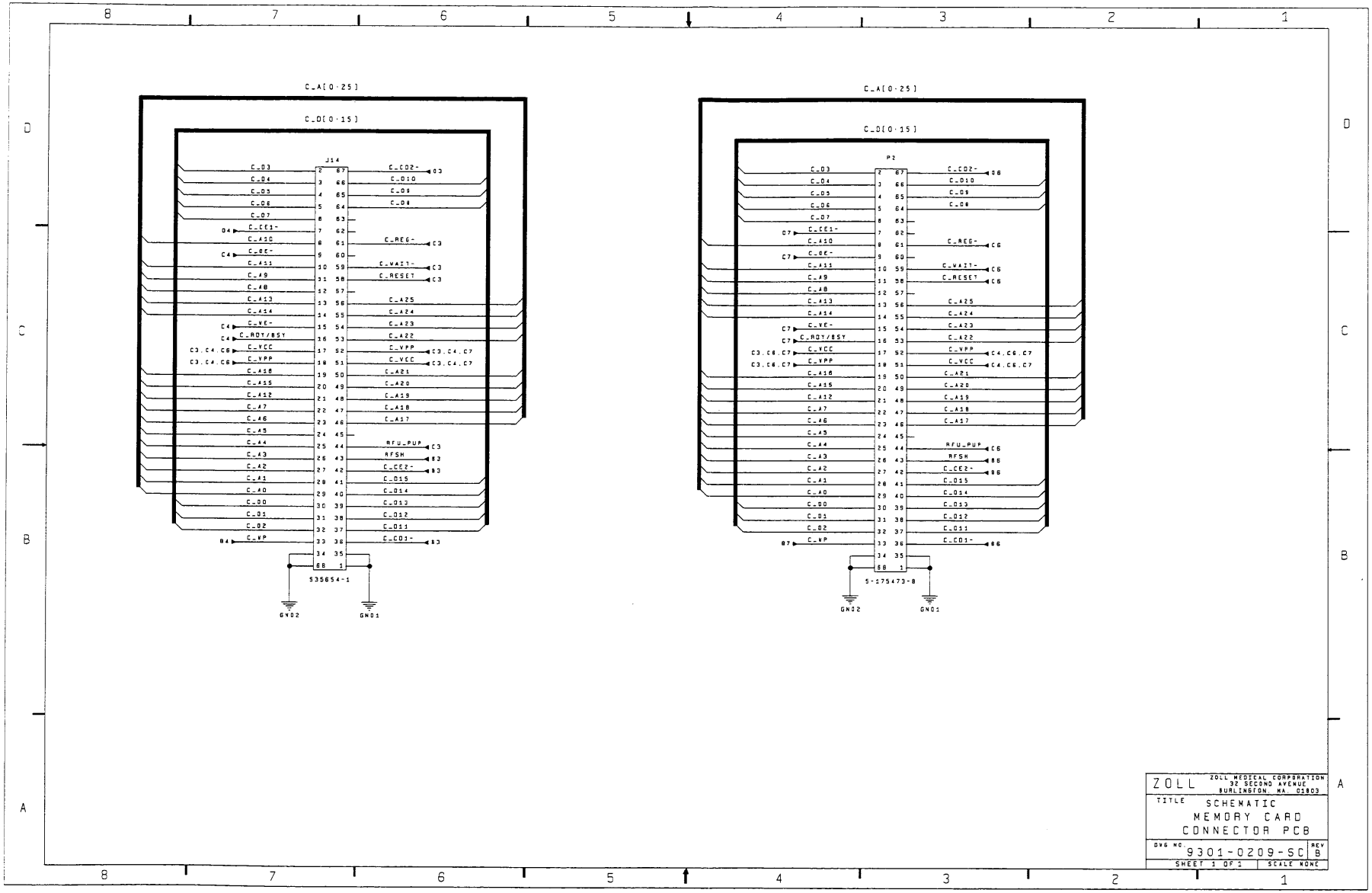


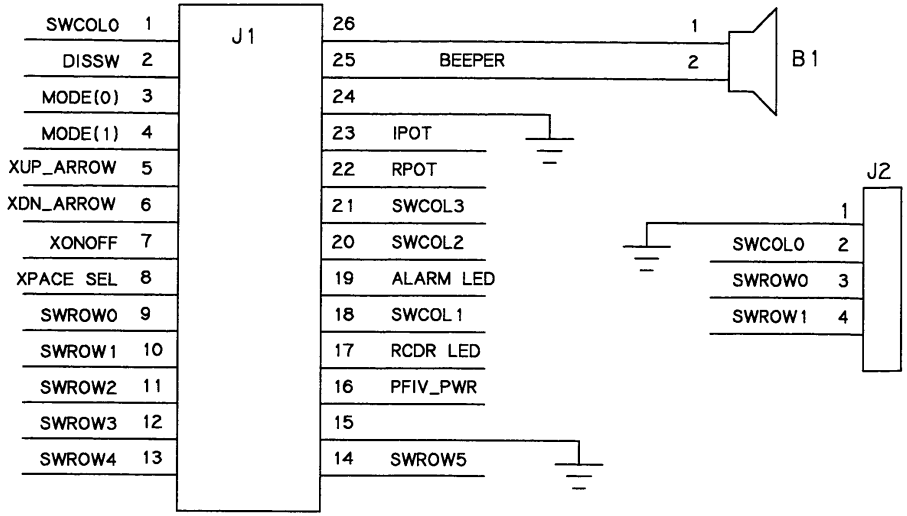
LAST REF.DES.	MISSING REF.DES.
U5	XXX
LCL1	XXX
R19	R17
CR1	XXX
C32	XXX
Y2	XXX
L1	XXX

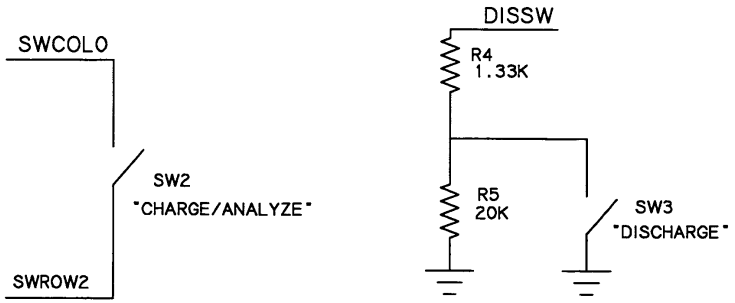
ZOLL	**ZOLL** MEDICAL COPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	**SCHEMATIC, AUDIO DSP BOARD**
DWG NO. **9301-0206-SC**	REV **A**
SHT **3** OF **3**	SCALE: **NONE**

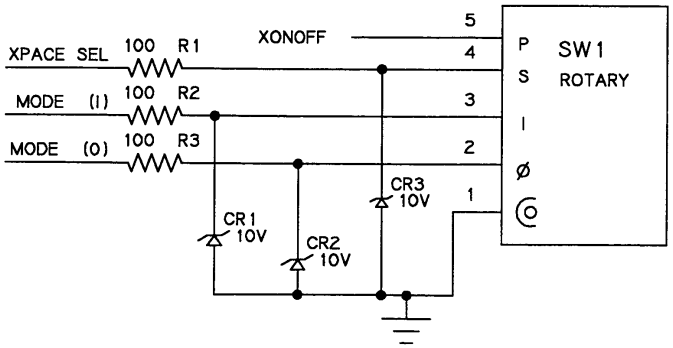


ZOLL	**ZOLL** MEDICAL COPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	**SCHEMATIC COMMUNICATIONS CONNECTOR**
DWG NO. **9301-0208-SC**	REV **A**
SHT **1** OF **1**	SCALE: **NONE**


C_A[0..25]
C_D[0..15]
J14
535654-1
GND2
GND1
C_A[0..25]
C_D[0..15]
P2
5-175473-8
GND2
GND1
ZOLL
ZOLL MEDICAL CORPORATION
32 SECOND AVENUE
BURLINGTON, MA. 01803
TITLE
SCHEMATIC
MEMORY CARD
CONNECTOR PCB
DWG NO. 9301-0209-SC
REV B
SHEET 1 OF 1
SCALE NONE







ROTARY SWITCH TABLE

SWITCH POSITION	ⓒ: COMMON	Ø: MODE (0)	I: MODE (I)	S: PACE SEL	P: XONOFF	MODE
1 *	X		X	X	X	PACE
2	X	X	X			OFF
3	X	X			X	AED

* SWITCH POSITION 1
NOT AVAILABLE IN NON-PACING UNITS

ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	SCHEMATIC, PCB, MAIN CONTROL, 1600
DWG NO.	9301-0210-SC
REV.	A
SHT 1 OF 1	SCALE NONE

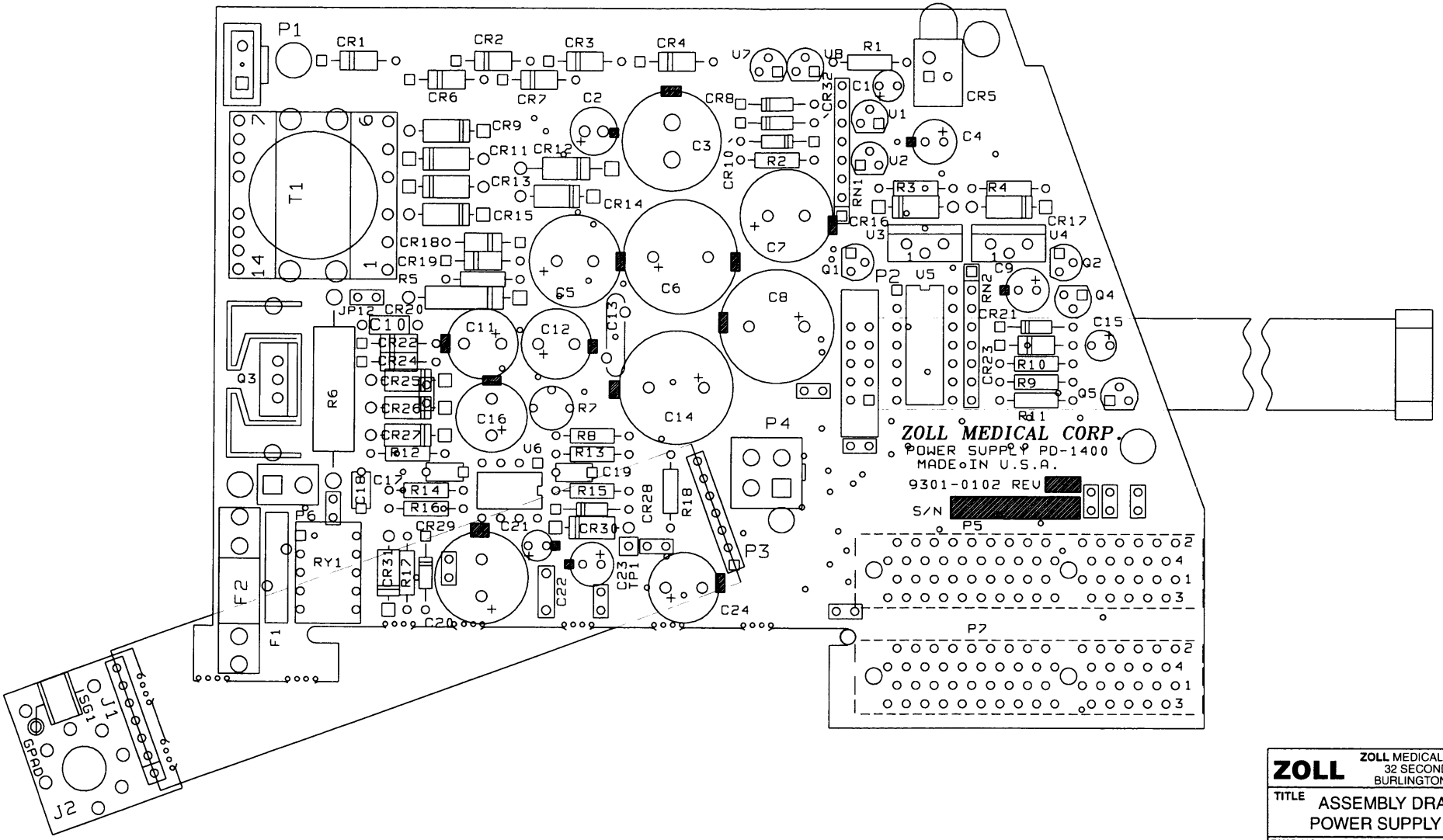
SECTION VI
COMPONENT LAYOUT DRAWINGS

ZOLL 1600 component layout drawings are included here to supplement the information presented in:

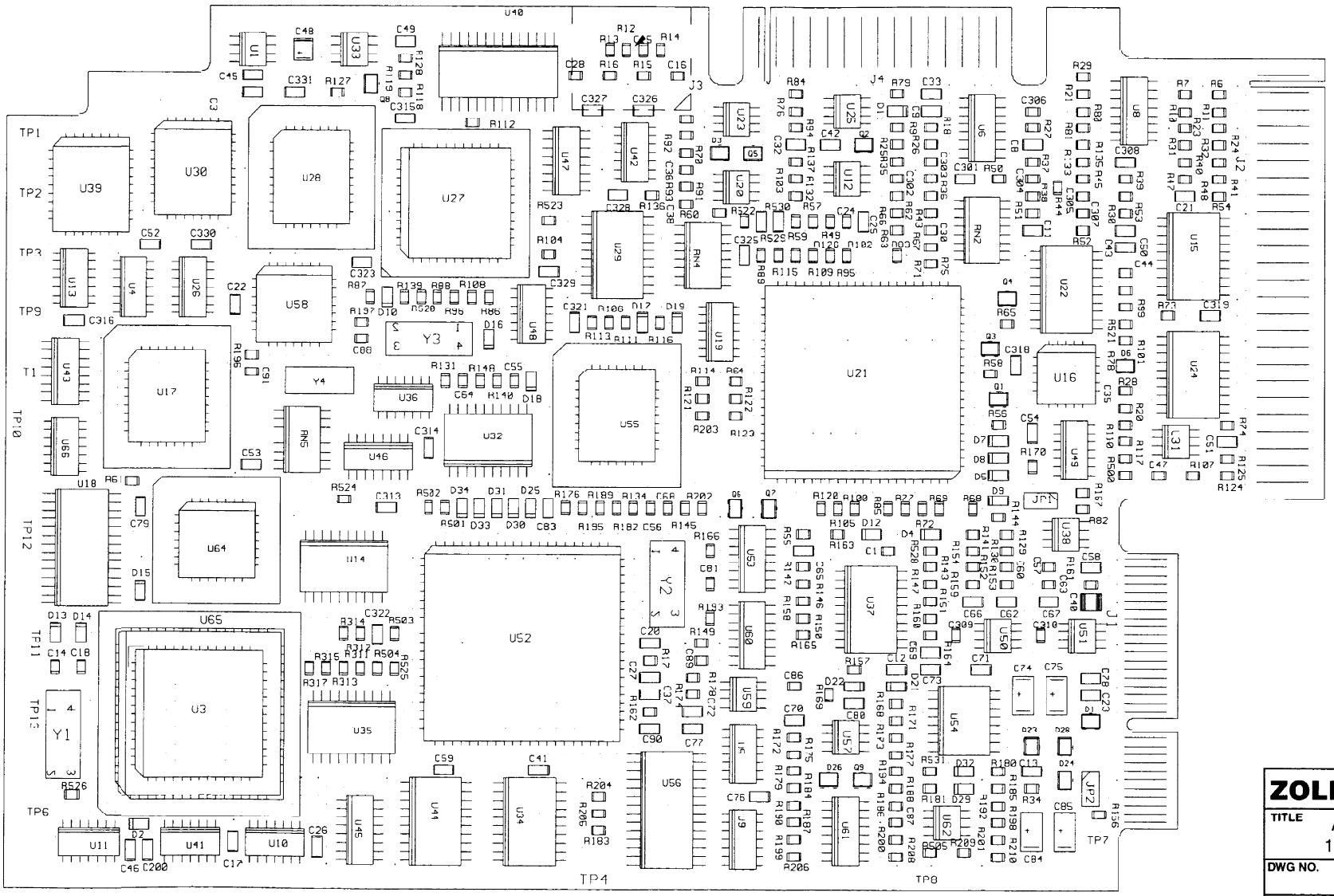
- Section III, Troubleshooting
- Section IV, Functional Descriptions
- Section V, Schematic Drawings

LIST OF DRAWINGS

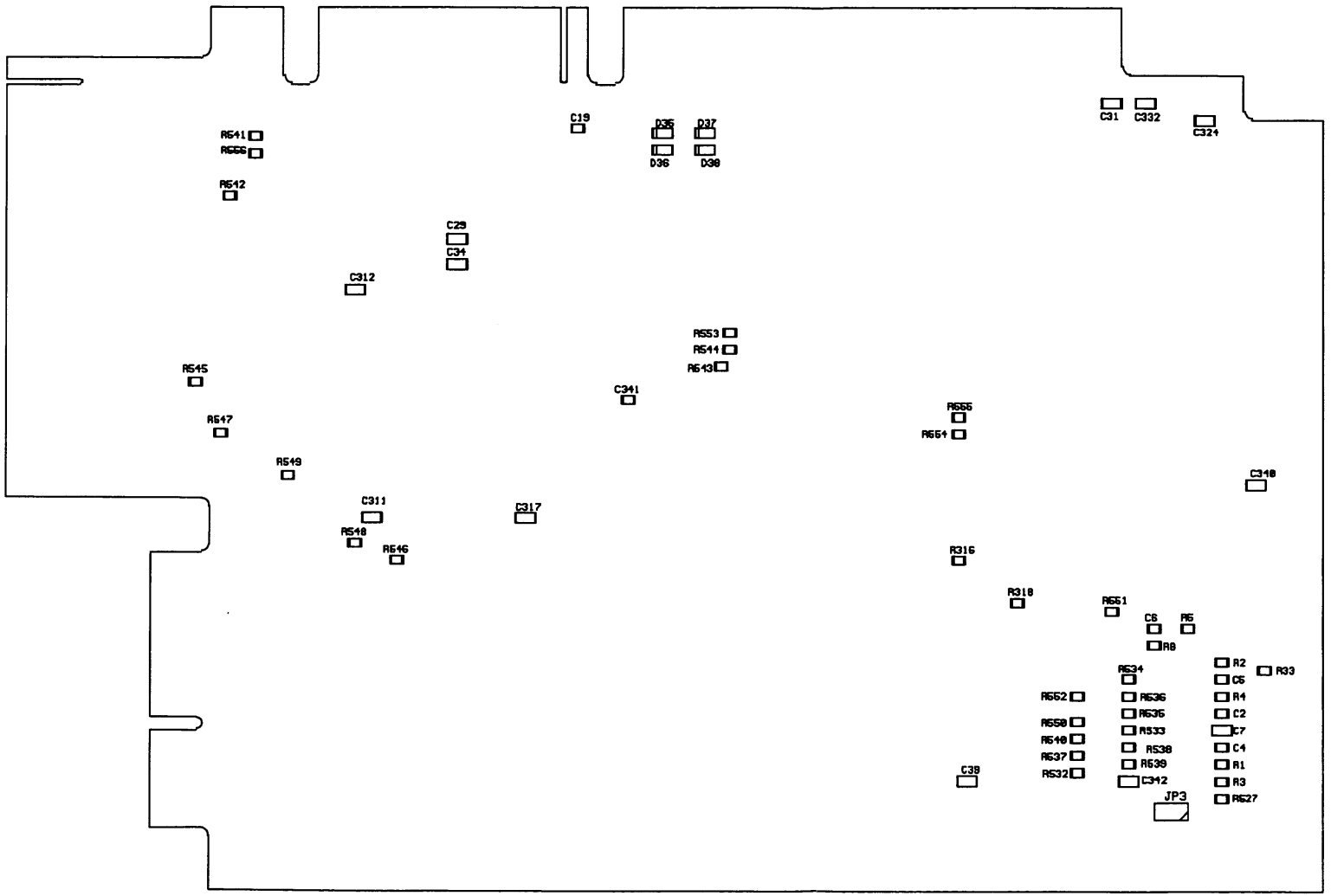
Description	Page
1. Power Supply Board	VI-3
2. Digital Module	VI-4
3. Analog	VI-6
4. Pacer/Defibrillator	VI-7
5. Module Interface	VI-8
6. Charger Port	VI-8
7. Module Port	VI-9
8. Main Cable	VI-10
9. Recorder Interface	VI-11
10. Main MRM Section I	VI-12
11. Main MRM Section II	VI-14
12. Audio DSP Board	VI-16
13. Communications Connection	VI-17
14. Memory Card Connector	VI-17
15. Main Control	VI-18



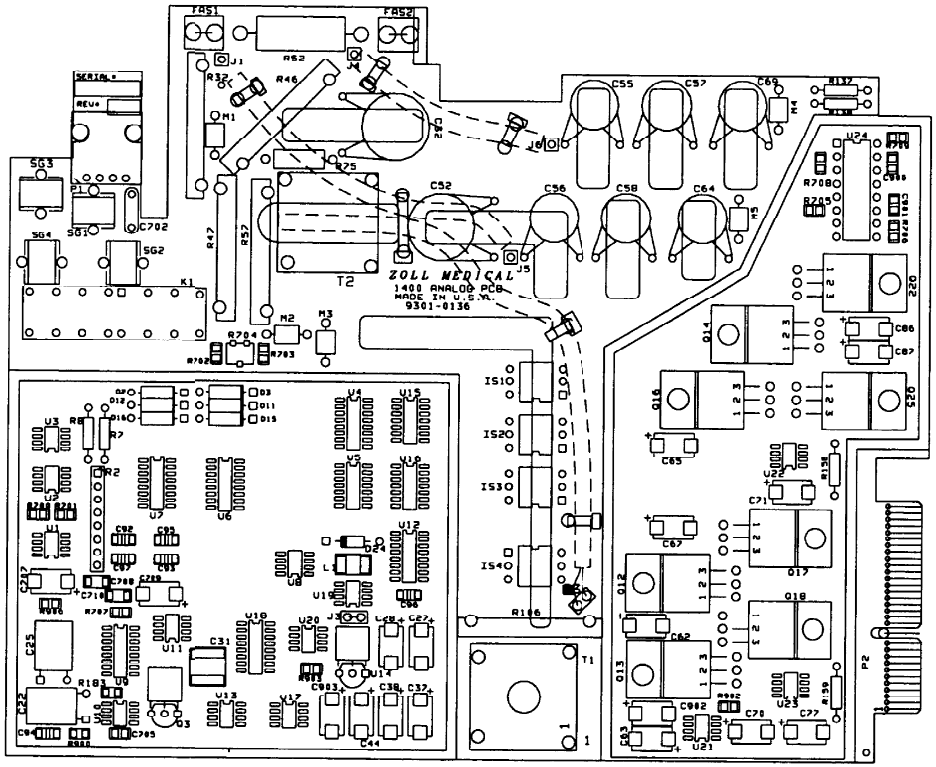
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803		
TITLE	ASSEMBLY DRAWING, POWER SUPPLY BOARD		
DWG NO.	9301-0102-AD	REV.	A
SHT 1 OF 1		SCALE	NONE

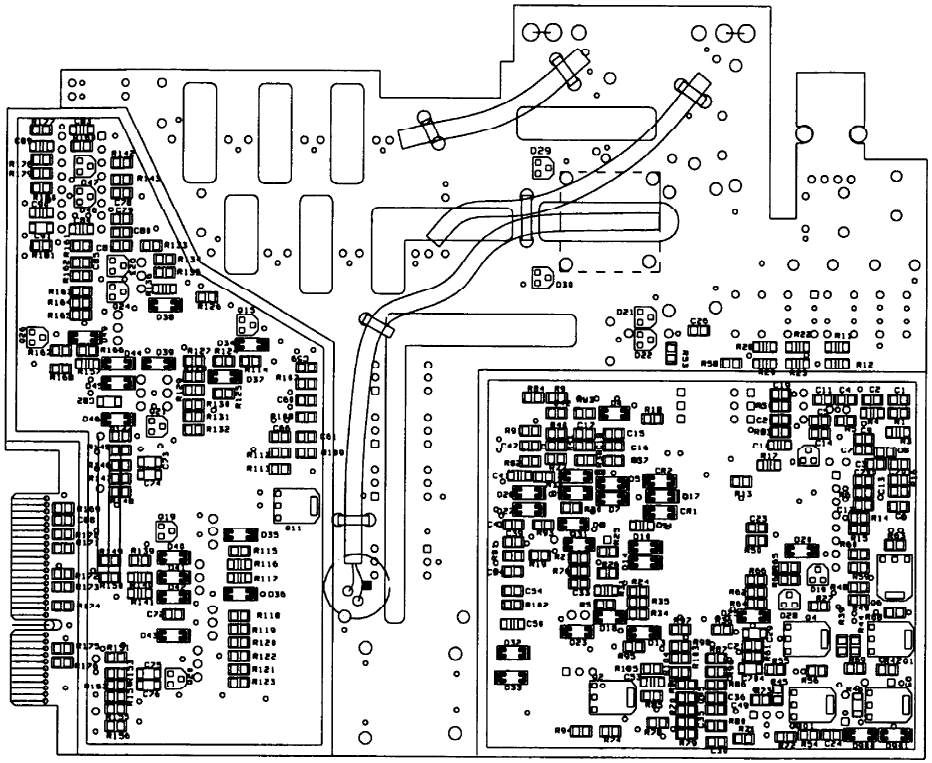


ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY DRAWING, 16 MHZ DIGITAL BOARD
DWG NO.	9301-0138-AD
REV.	B
SHT 1 OF 2	SCALE NONE

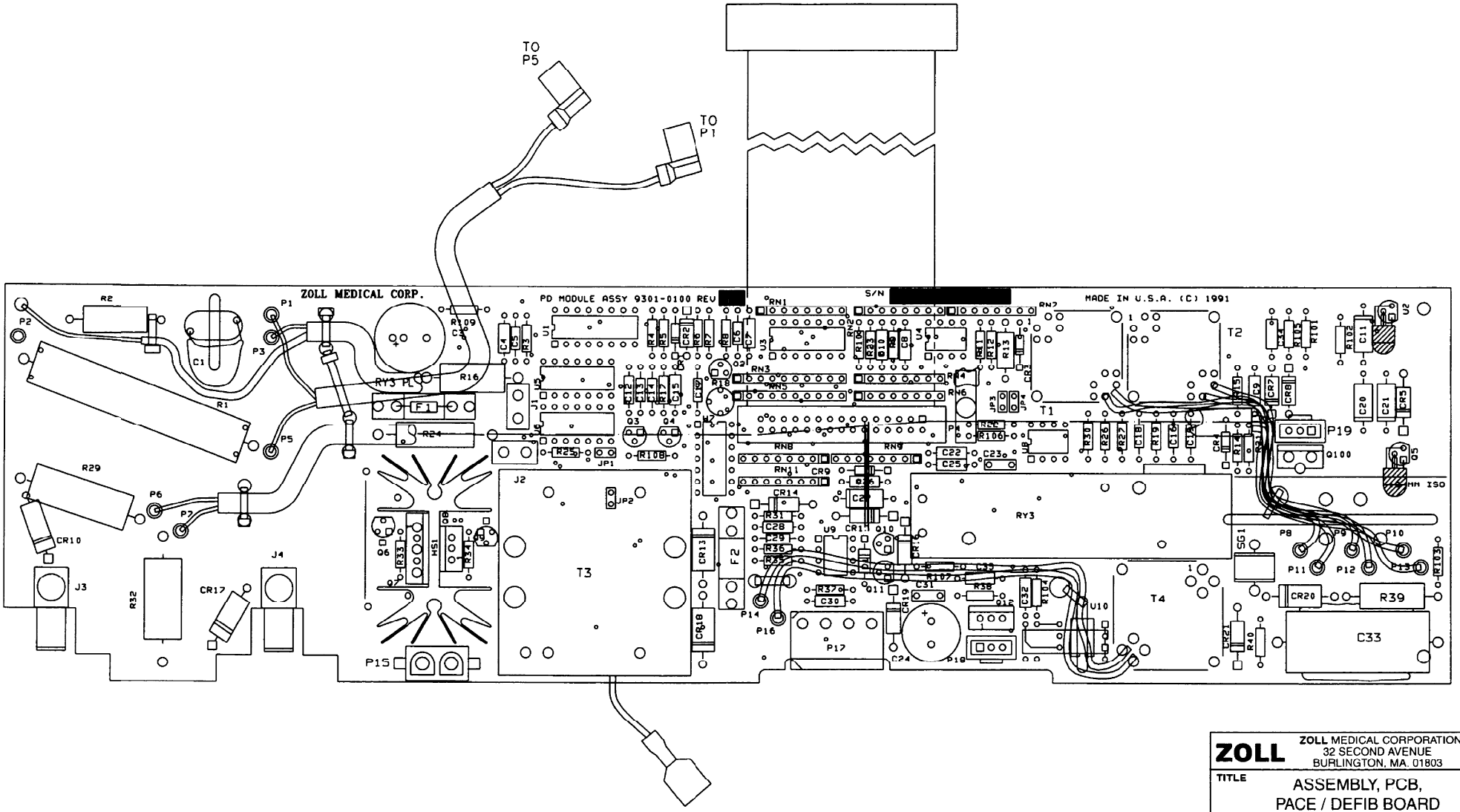


ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	ASSEMBLY DRAWING, 16 MHZ DIGITAL BOARD	
DWG NO.	9301-0138-AD	REV. B
SHT 2 OF 2	SCALE NONE	

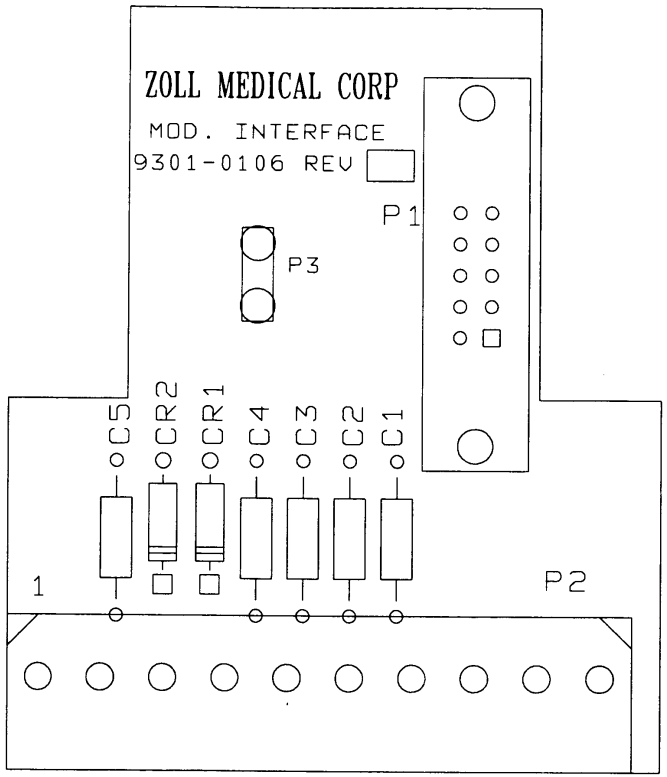




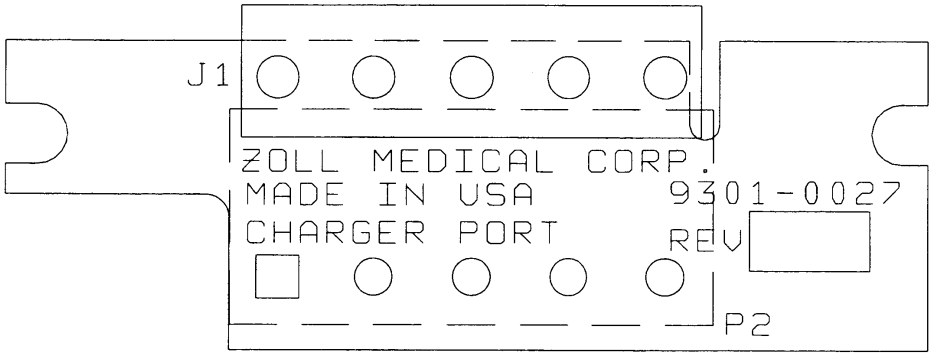
ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803		
TITLE ASSEMBLY DRAWING, ANALOG BOARD W/ IMPEDANCE CIRCUIT			
DWG NO. 9301-0136-AD		REV. E	
SHT 1	OF 1	SCALE NONE	



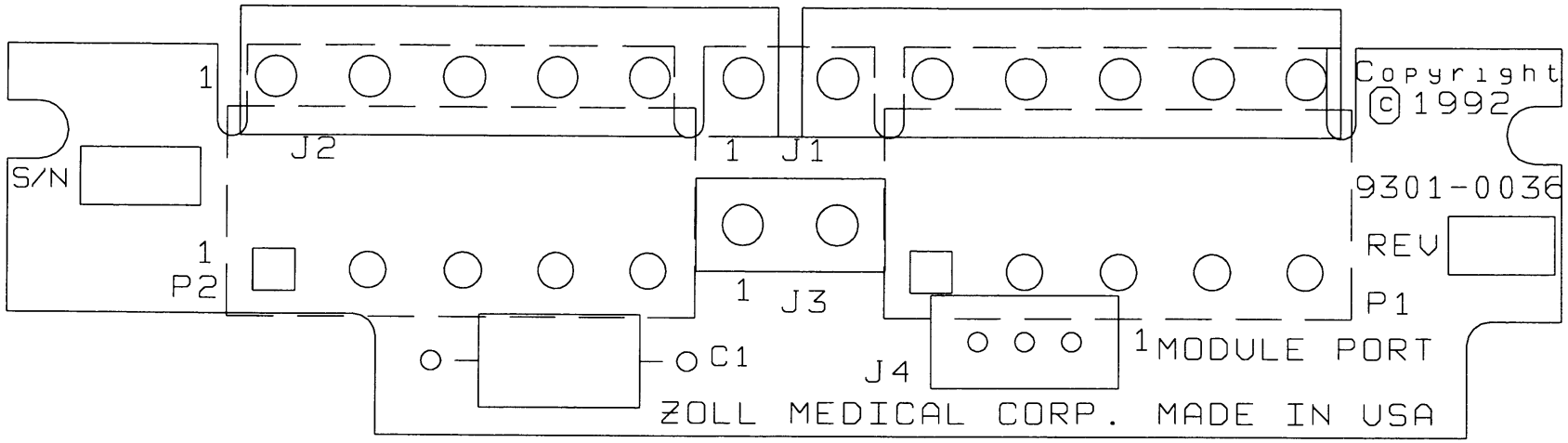
ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY, PCB, PACE / DEFIB BOARD
DWG NO.	9301-0100-AD
REV.	A
SHT 1 OF 1	SCALE NONE



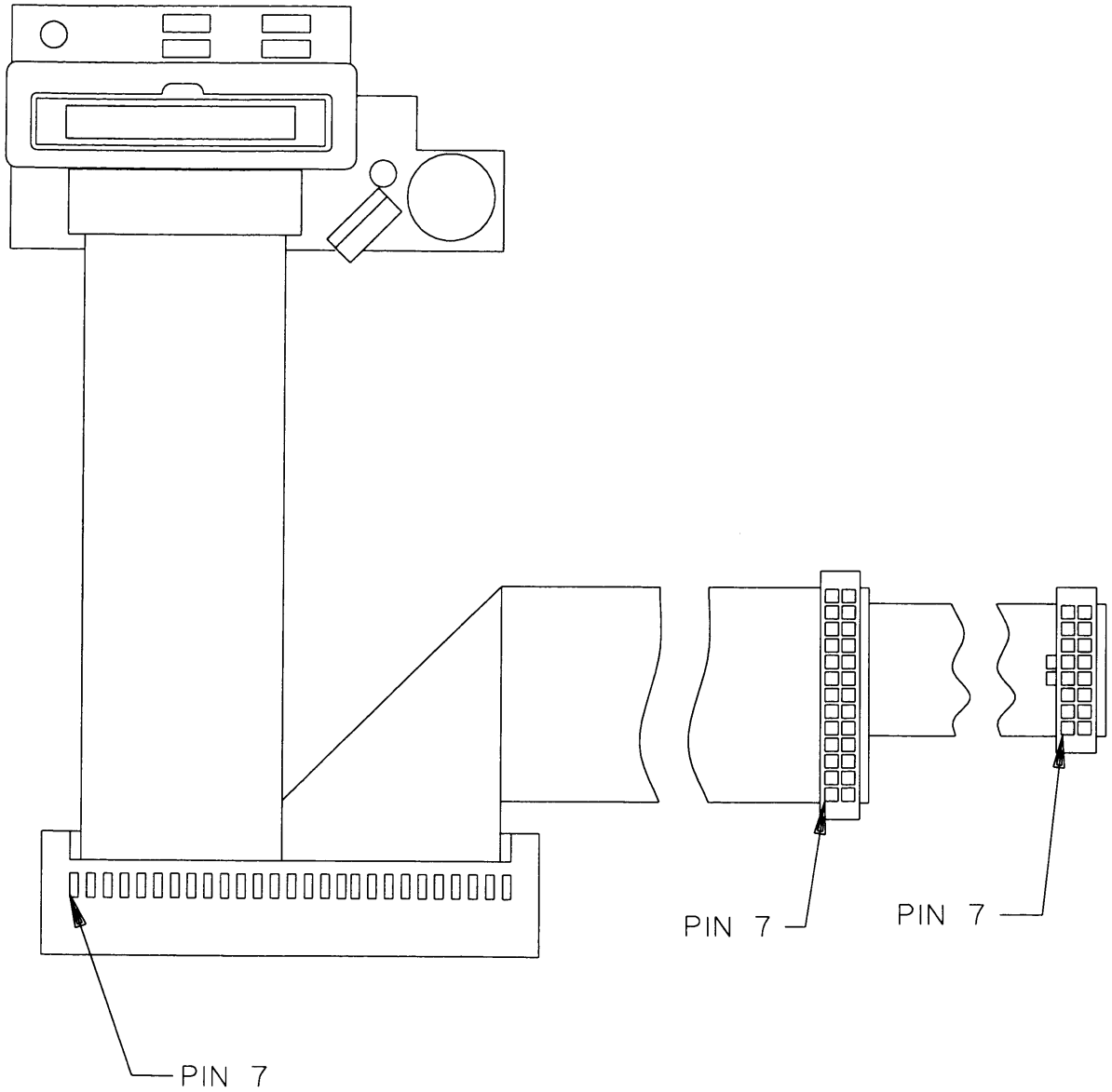
ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY DRAWING, MODULE INTERFACE
DWG NO. 9301-0106-AD	REV. A
SHT 1 OF 1	SCALE NONE



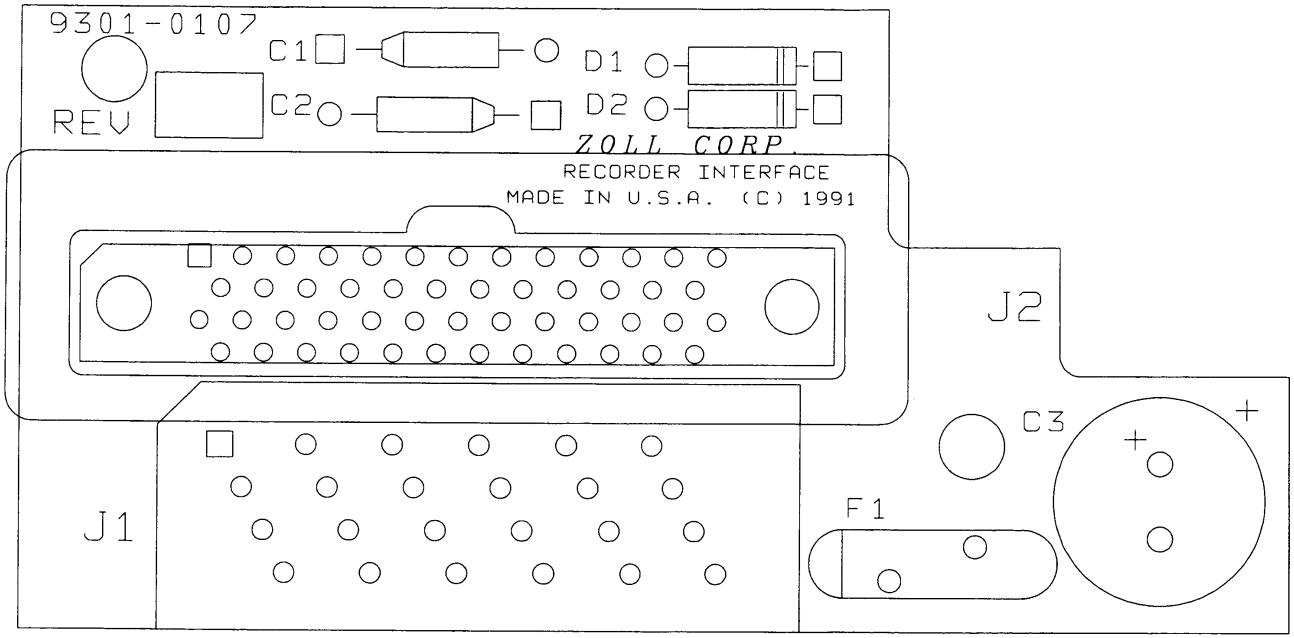
ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY DRAWING, PCB, CHARGER PORT
DWG NO. 9301-0027-AD	REV. A
SHT 1 OF 1	SCALE NONE



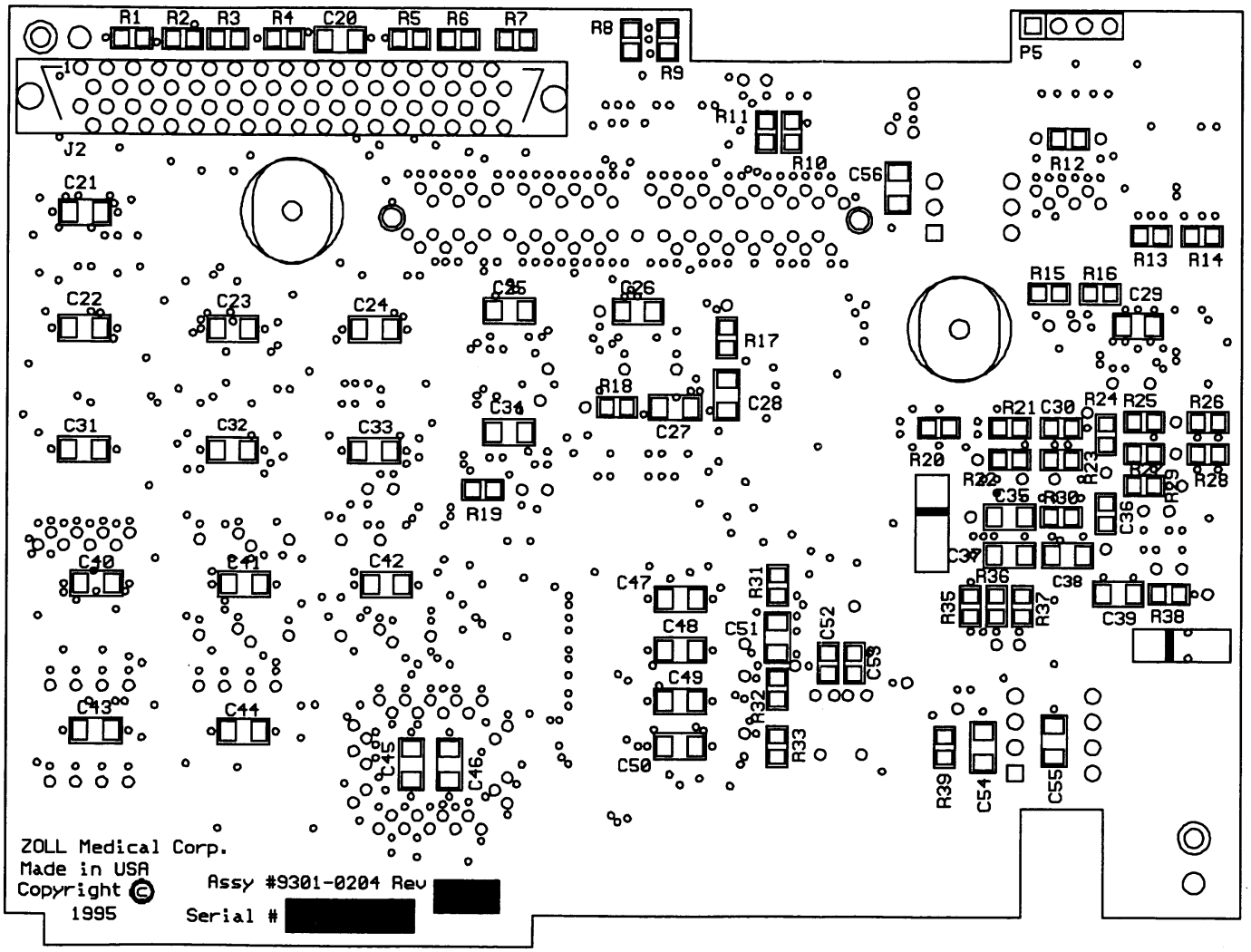
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY DRAWING, PCB MODULE PORT
DWG NO. 9301-0036-AD	REV. A
SHT 1 OF 1	SCALE NONE



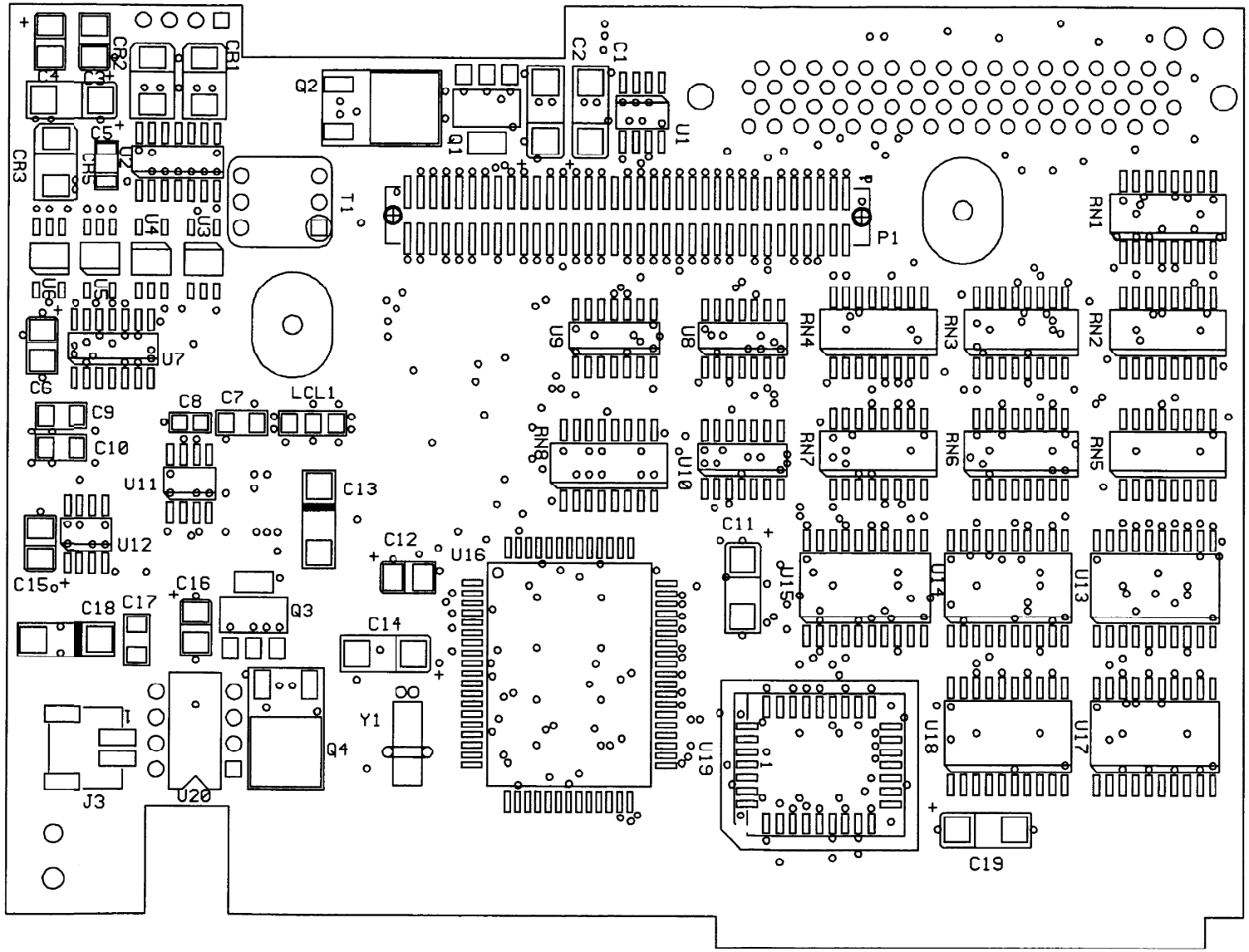
ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY, MAIN CABLE
DWG NO.	9500-0202
REV.	A
SHT 1 OF 1	SCALE NONE



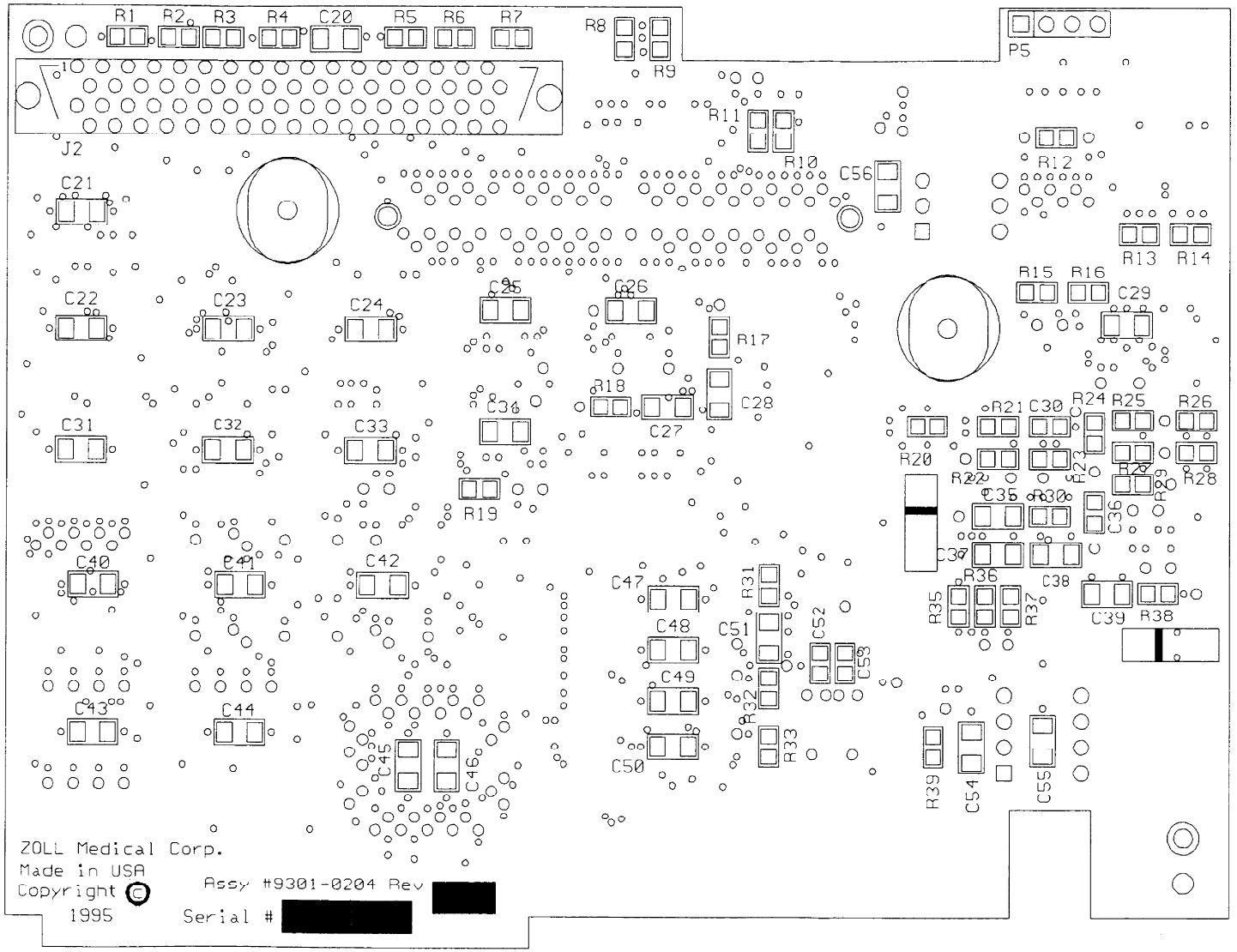
ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY DRAWING, PCB RECORDER INTERFACE
DWG NO. 9301-0107-AD	REV. B
SHT 1 OF 1	SCALE NONE



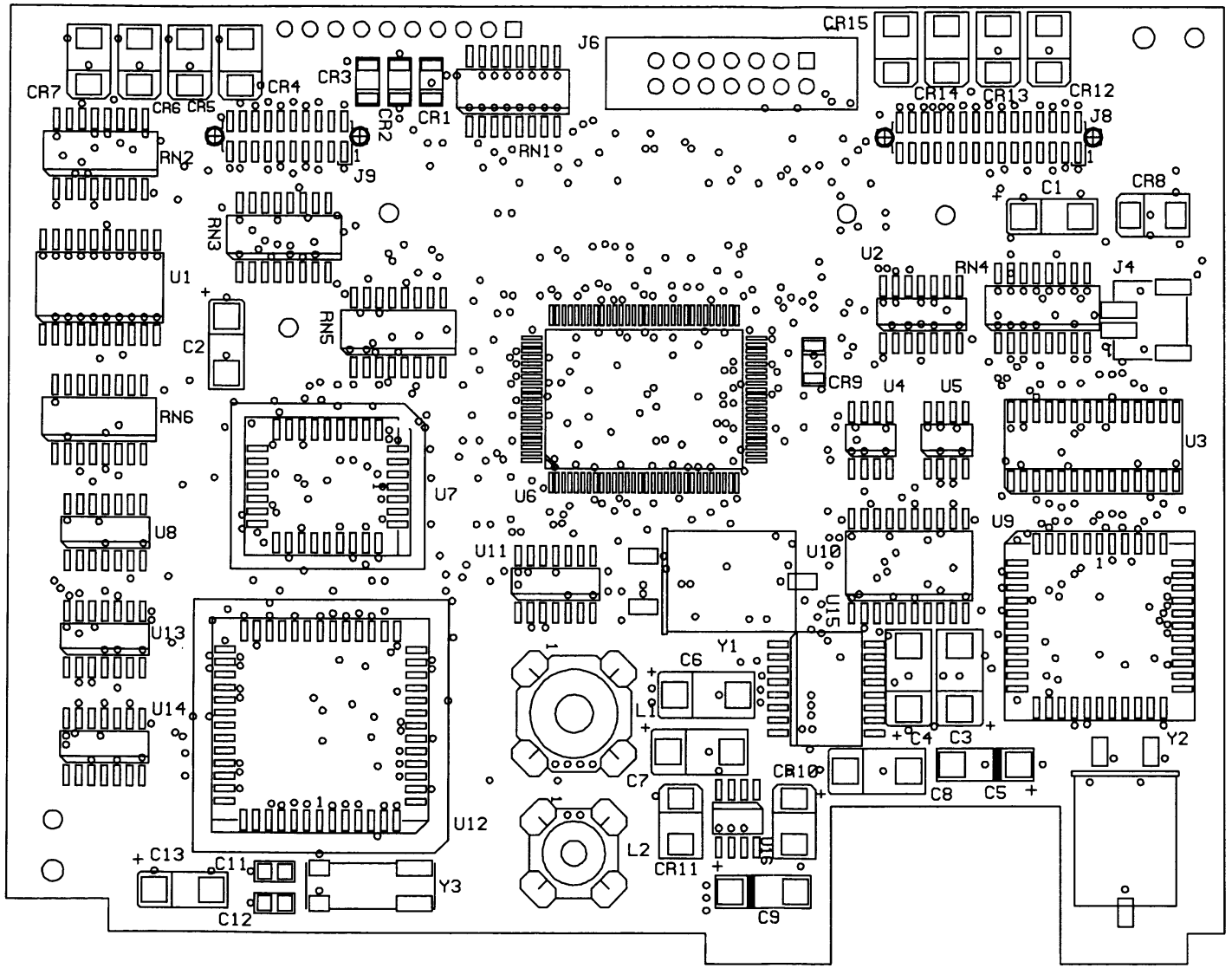
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY, PCB, MRM, MAIN BOARD - SEC - I
DWG NO.	9301-0204-AD
REV.	B
SHT 1 OF 2	SCALE NONE



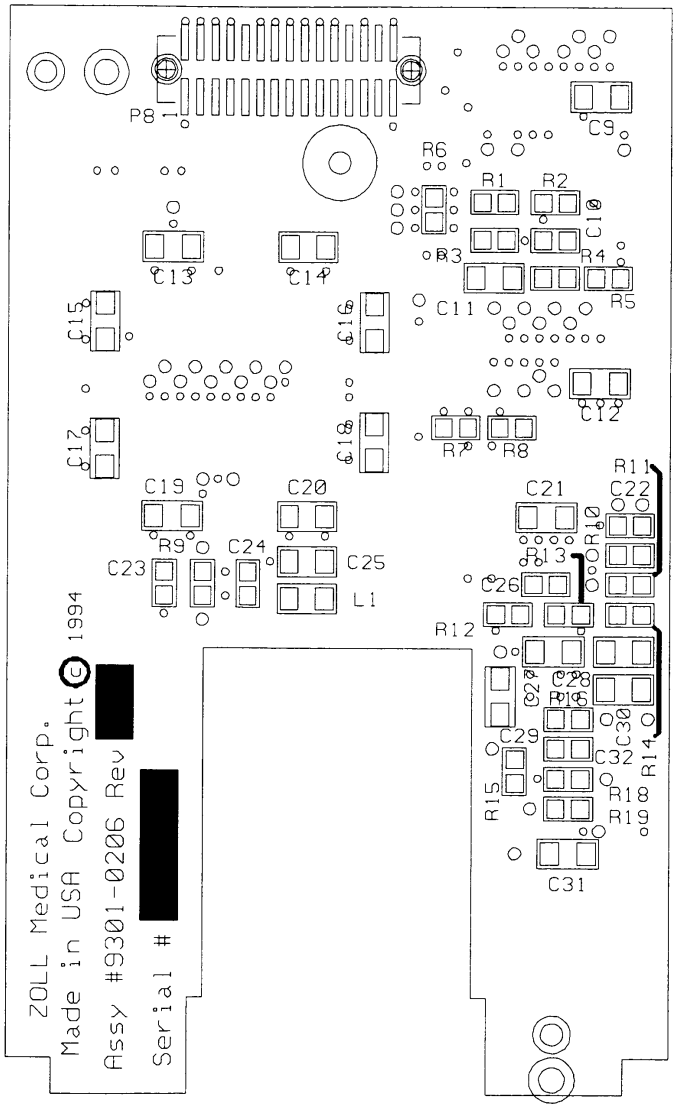
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY, PCB, MRM, MAIN BOARD - SEC - I
DWG NO. 9301-0204-AD	REV. B
SHT 2 OF 2	SCALE NONE

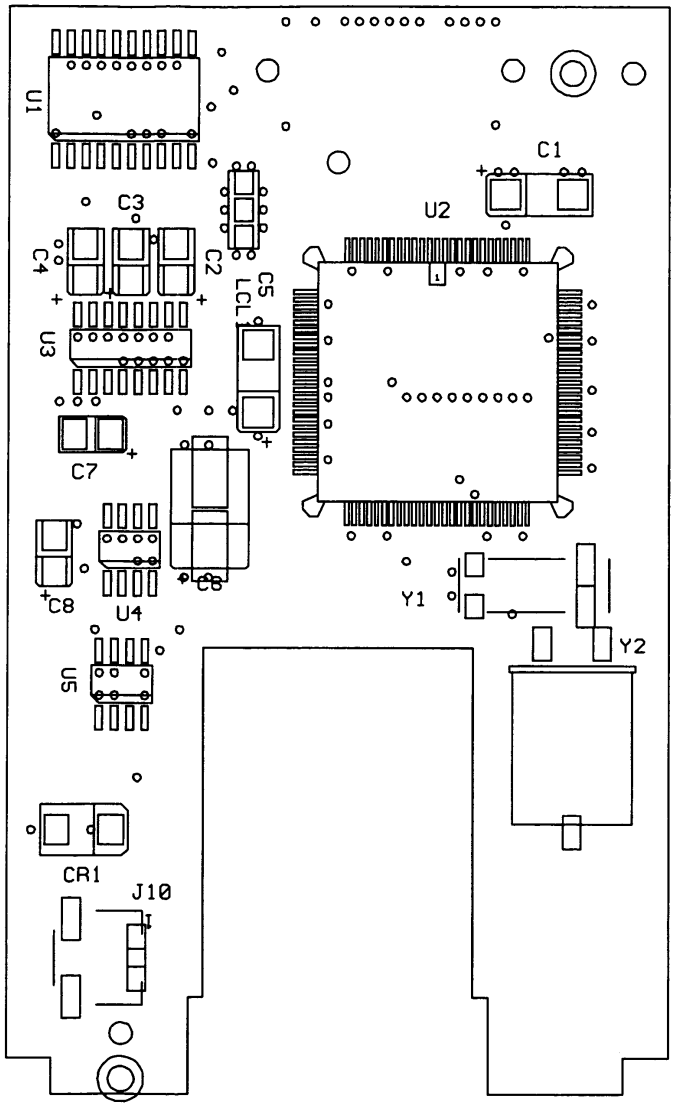


ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY, PCB, MRM, MAIN BOARD - SEC - II
DWG NO.	9301-0205-AD
REV.	C
SHT 1 OF 2	SCALE NONE

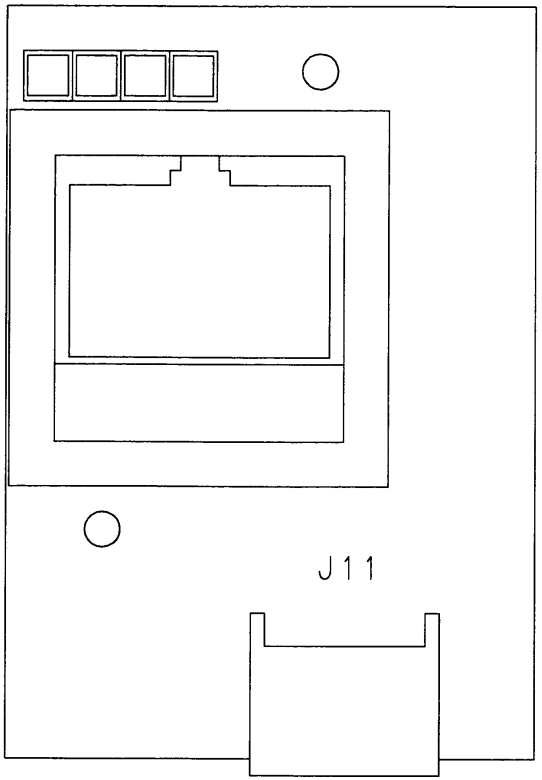


ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	ASSEMBLY, PCB, MRM, MAIN BOARD - SEC - II	
DWG NO.	9301-0205-AD	REV. C
SHT 2 OF 2	SCALE NONE	

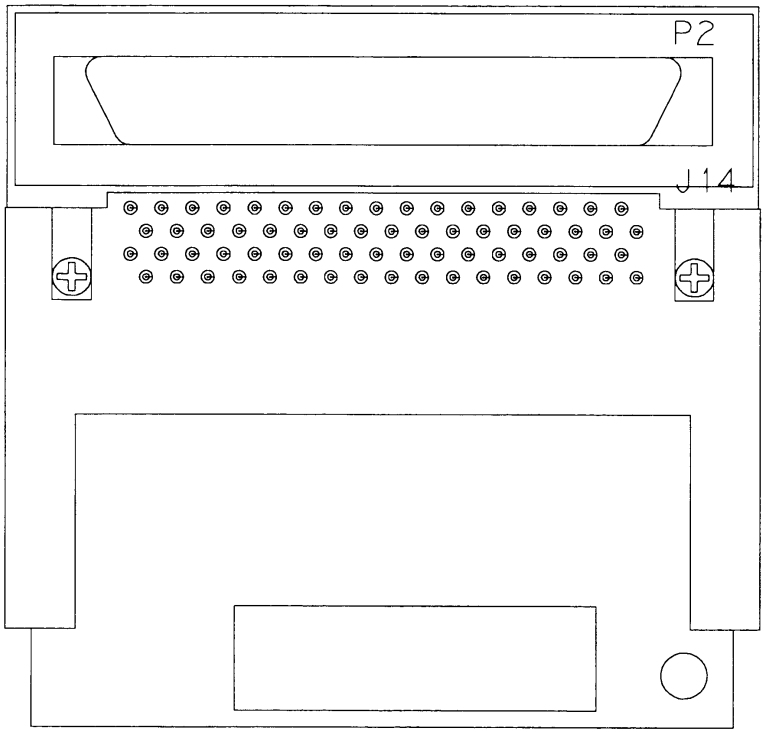




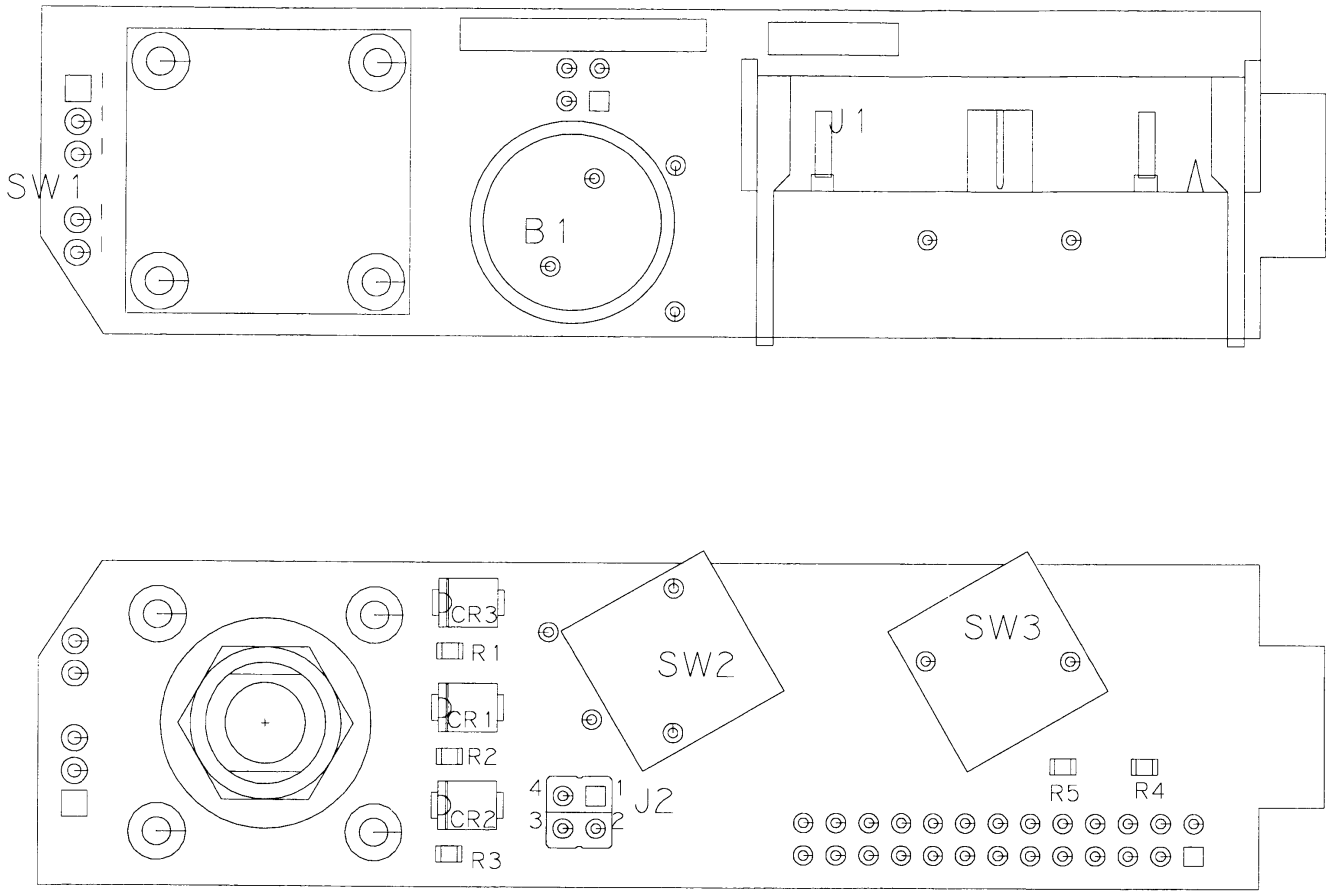
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	ASSEMBLY DRAWING, PCB, AUDIO DSP BOARD	
DWG NO.	9301-0206-AD	REV. A
SHT 1 OF 1	SCALE NONE	



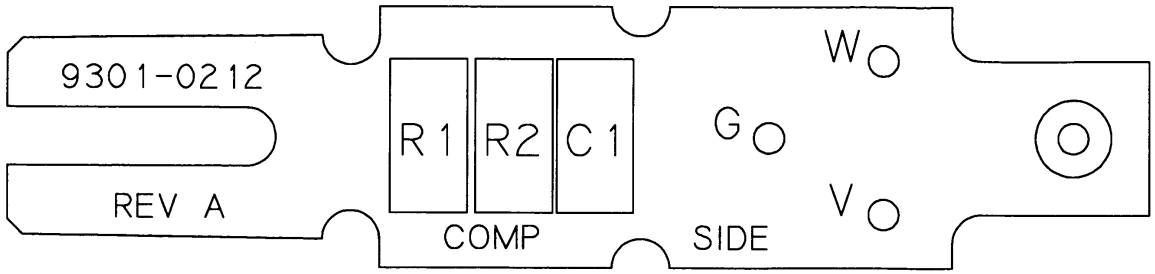
ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	ASSEMBLY DRAWING, PCB, COMMUNICATIONS CONNECTOR	
DWG NO.	9301-0208-AD	REV. C
SHT 1 OF 1	SCALE NONE	

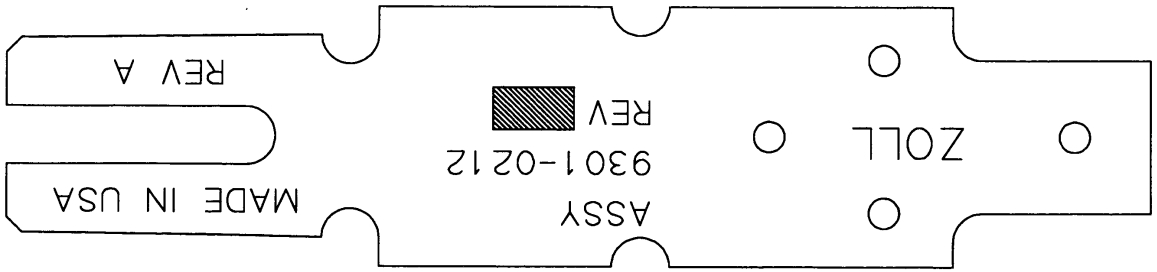


ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE	ASSEMBLY, PCB, MEMORY CARD CONNECTOR	
DWG NO.	9301-0209-AD	REV. B
SHT 1 OF 1	SCALE NONE	



ZOLL	**ZOLL** MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE	ASSEMBLY DRAWING, PCB, MAIN CONTROL 1600
DWG NO. 9301-0210-AD	REV. B
SHT 1 OF 1	SCALE NONE





ZOLL	ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE: ASSEMBLY DRAWING, PRINTED WIRING BOARD, MFE CABLE	
DWG NO. 9301-0212-AD	REV. B
SHT 1 OF 1	SCALE NONE

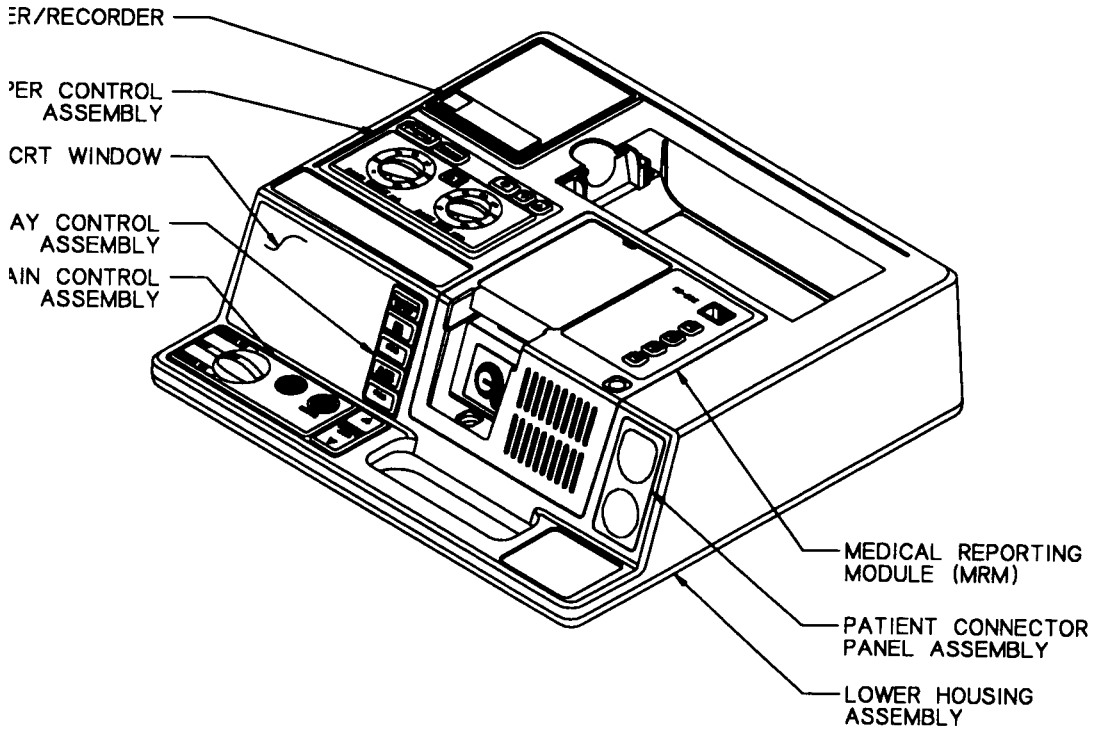
SECTION VII
DISASSEMBLY PROCEDURES

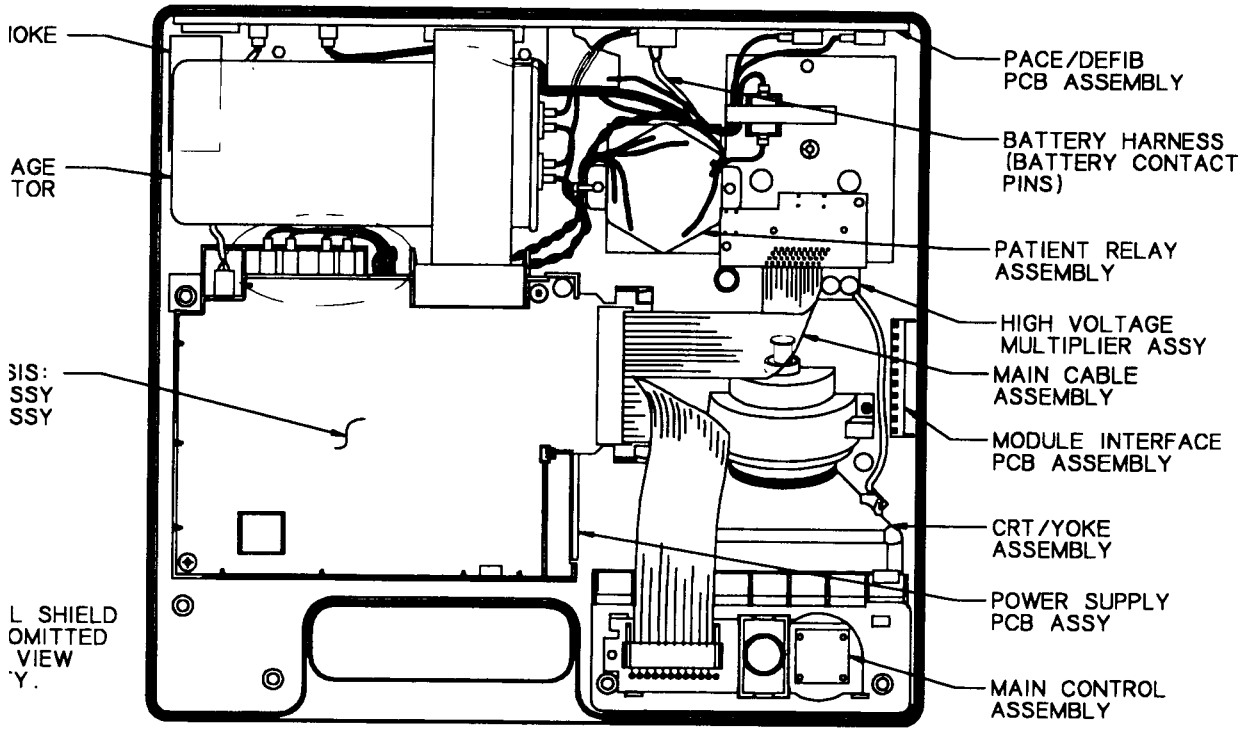
This section is designed to assist in the removal and replacement of ZOLL 1600 components. Be sure to observe anti-static precautions whenever the unit is open.

WARNING

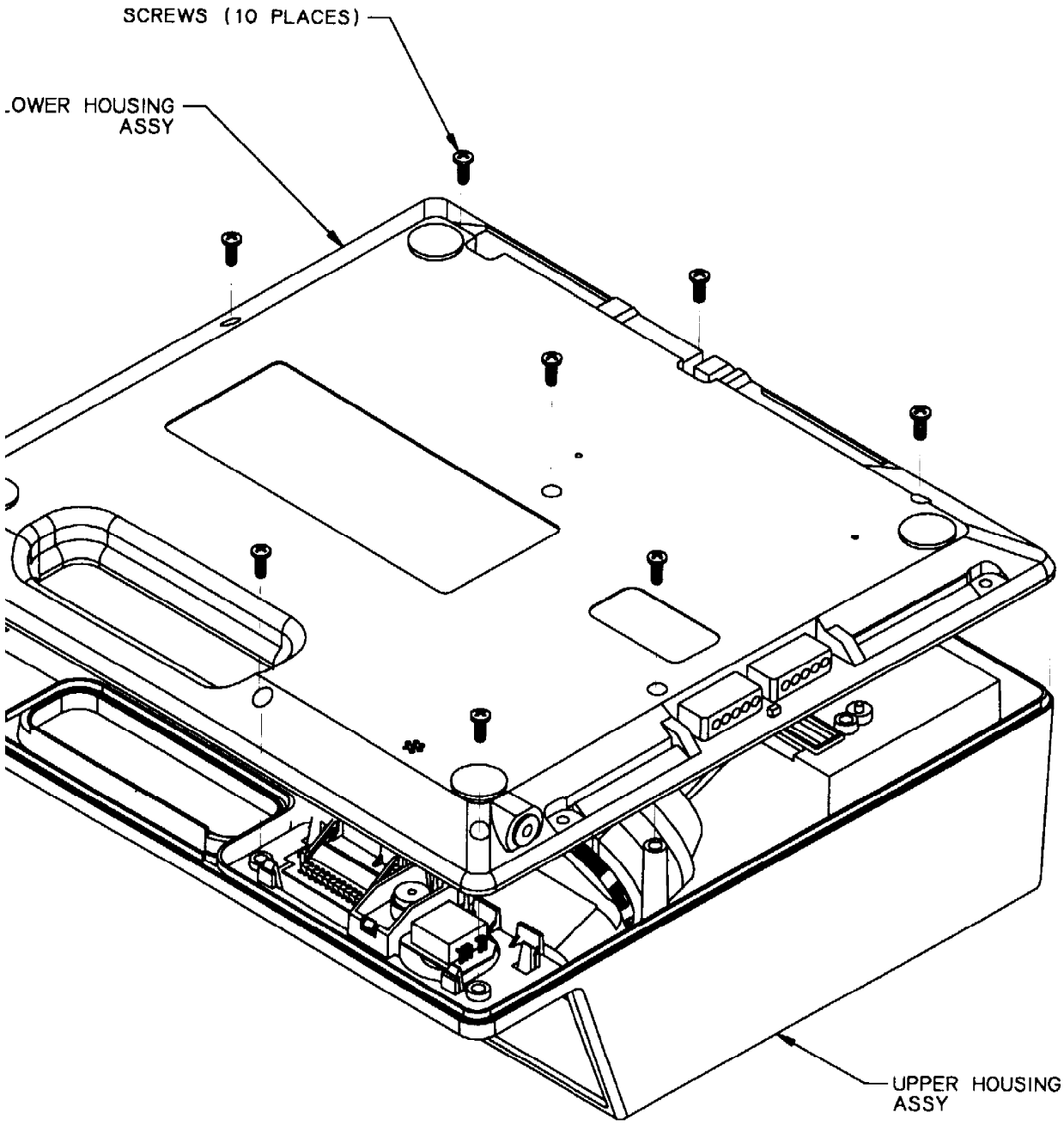
- LETHAL VOLTAGES EXIST WITHIN THIS UNIT. ZOLL 1600-SERIES UNITS SHOULD BE SERVICED BY QUALIFIED PERSONNEL ONLY!
- **Be sure to remove the battery pack from the unit before removing any components.**

Note: Cable paths and connector locations should be noted prior to disassembly. If cables are run in locations other than those indicated by the manufacturer, the unit may not close properly.


ER/RECORDER
PER CONTROL ASSEMBLY
CRT WINDOW
AY CONTROL ASSEMBLY
AIN CONTROL ASSEMBLY
MEDICAL REPORTING MODULE (MRM)
PATIENT CONNECTOR PANEL ASSEMBLY
LOWER HOUSING ASSEMBLY


IOKE
AGE TOR
SIS: SSY SSY
L SHIELD OMITTED VIEW Y.
PACE/DEFIB PCB ASSEMBLY
BATTERY HARNESS (BATTERY CONTACT PINS)
PATIENT RELAY ASSEMBLY
HIGH VOLTAGE MULTIPLIER ASSY
MAIN CABLE ASSEMBLY
MODULE INTERFACE PCB ASSEMBLY
CRT/YOKE ASSEMBLY
POWER SUPPLY PCB ASSY
MAIN CONTROL ASSEMBLY

Description		Page
Lower Housing Assembly		VII-5
Printer/Recorder	ZOLL 1600 Paramedic, Advanced, Intermediate	VII-7
Filler Kit, Recorder Well	ZOLL 1600 Basic	VII-7
Main Cable Assembly		VII-9
Main Control Assy (Pace/Defib)	ZOLL 1600 Paramedic	VII-11
Main Control Assy (Non-Pacing)	ZOLL 1600 Advanced, Intermediate, Basic	VII-11
CRT/Yoke Assembly		VII-13
Upper Control Assy (Pace/Defib)	ZOLL 1600 Paramedic	VII-15
Upper Control Assy (Non-Pace)	ZOLL 1600 Advanced, Intermediate, Basic	VII-15
CRT Window		VII-17
Display Control Assembly	ZOLL 1600 Paramedic, Advanced	VII-19
Display Control Assembly (Single Function)	ZOLL 1600 Intermediate, Basic	VII-19
High Voltage Multiplier Assembly		VII-21
Module Interface PCB Assembly		VII-23
Power Supply PCB Assembly		VII-25
Digital, Analog PCB Assembly		VII-27
Analog Advisory PCB Assembly		VII-27
High Voltage Capacitor Assembly		VII-29
Defib PCB Assembly		VII-31
Patient Relay Assembly		VII-33
Battery Harness Assembly		VII-35
Battery Contact Pin		VII-35
Patient Connector Panel Assembly		VII-37
Choke Assembly		VII-39
Medical Reporting Module (MRM)	ZOLL 1600 Paramedic, Advanced	VII-40
Medical Reporting Module (MRM)	ZOLL 1600 Intermediate, Basic	VII-40


SCREWS (10 PLACES)
LOWER HOUSING ASSY
UPPER HOUSING ASSY

1. REMOVING THE LOWER HOUSING ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

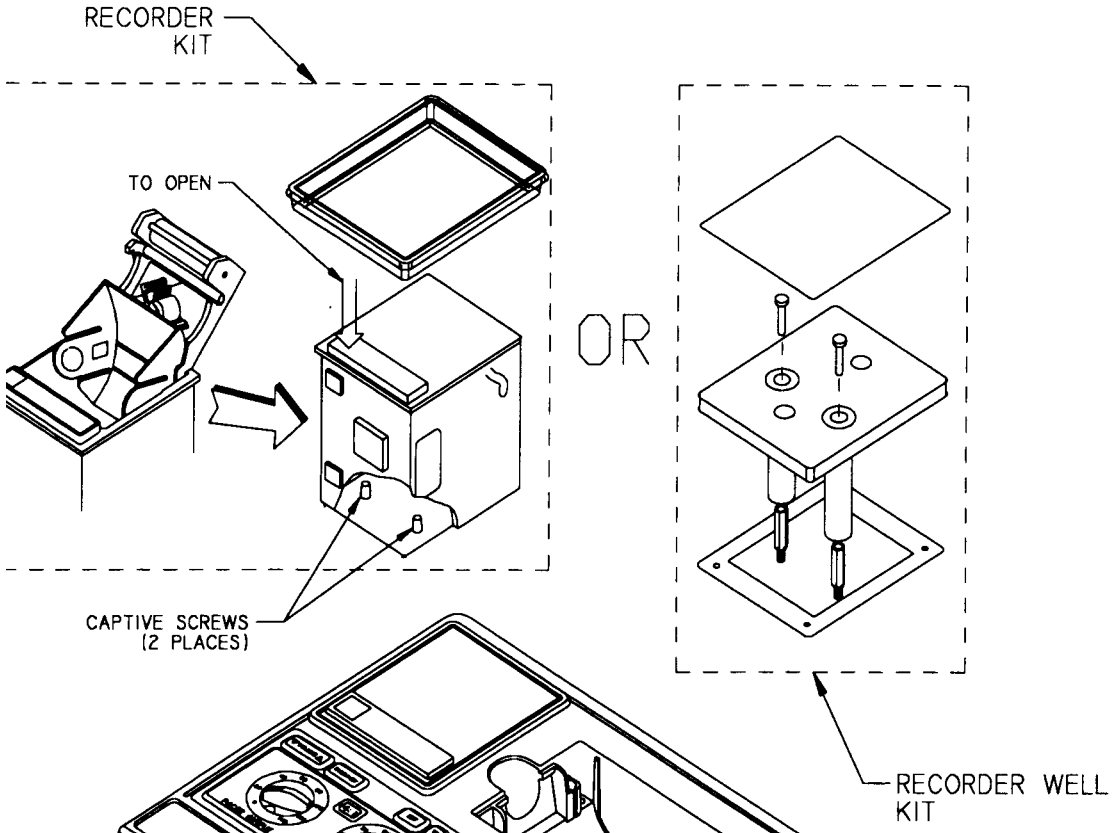
1. Remove 10 (ten) 6-32 x 5/16 screws as shown in the illustration.
2. Lift lower housing assembly straight up and remove.

INSTALLING THE LOWER HOUSING ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

1. Reverse steps 1 & 2 above.


RECORDER
KIT
TO OPEN
OR
CAPTIVE SCREWS
(2 PLACES)
RECORDER WELL
KIT

2. REMOVING THE PRINTER/RECORDER OR RECORDER WELL FILLER KIT

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

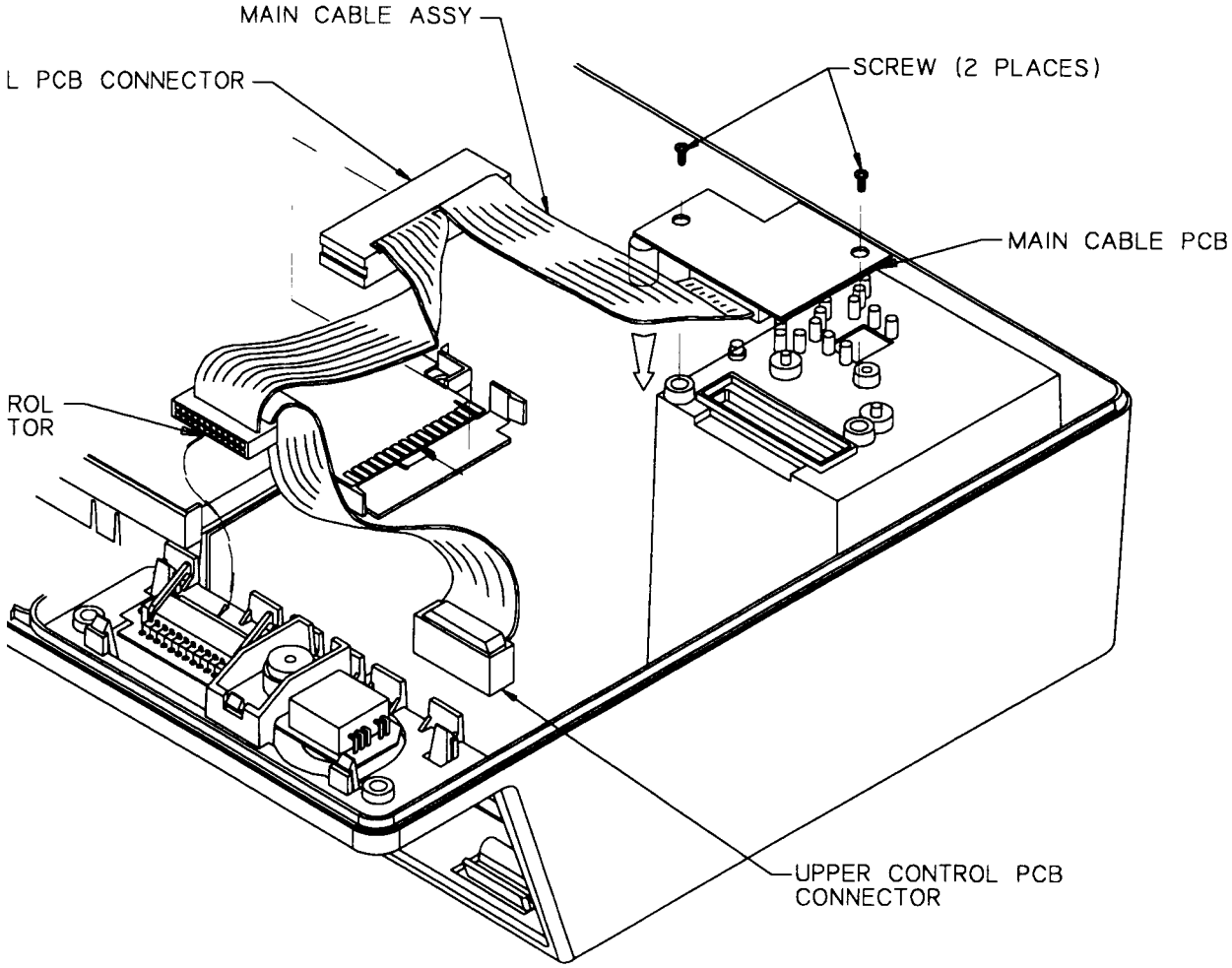
1. Open the Printer/Recorder door and loosen the 2 (two) captive mounting screws where indicated.
2. Lift printer/recorder or recorder well filler kit straight out.
3. Remove and retain rubber gasket from printer/recorder.

STALLING THE PRINTER/RECORDER

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

1. Replace rubber gasket on the printer recorder.
2. Reverse steps 1 & 2 above.


MAIN CABLE ASSY
L PCB CONNECTOR
SCREW (2 PLACES)
MAIN CABLE PCB
ROL
TOR
UPPER CONTROL PCB
CONNECTOR

3. REMOVING THE MAIN CABLE ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- X-Acto Knife

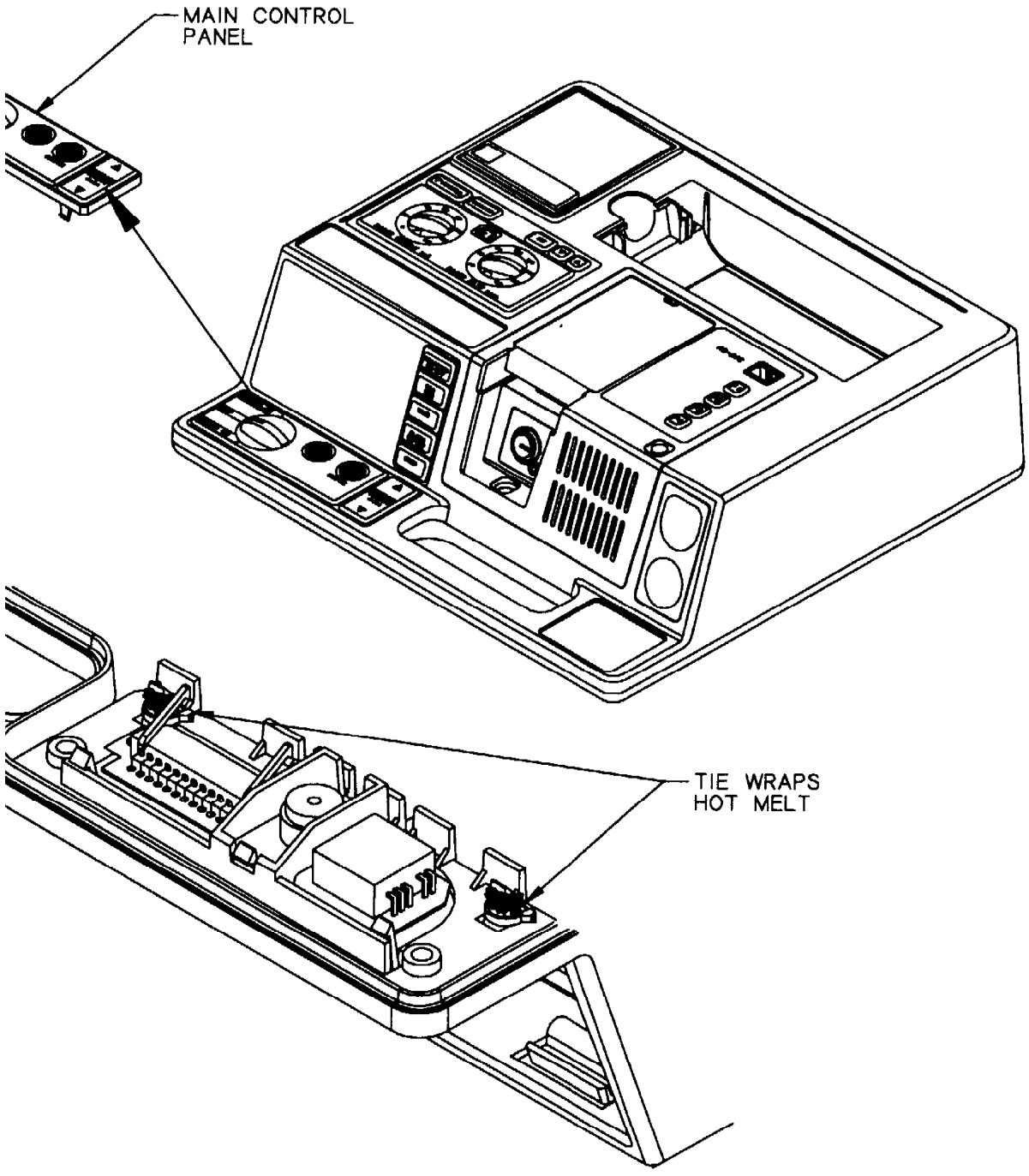
1. Remove lower housing assembly as shown on page VII-5.
2. Open the black lever latches on the Main Control PCB connector.
3. Disconnect main cable from main control PCB.
4. Disconnect main cable from digital PCB edge connector.
5. Disconnect main cable from upper control PCB connector.
6. Remove 2 (two) screws from main cable PCB where indicated.
7. Disconnect main cable PCB from printer/recorder connector.

ISTALLING THE MAIN CABLE ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

1. Check all gaskets for any rips or tears; replace if necessary.
2. Connect main cable PCB to printer/recorder connector.
3. Secure main cable PCB to recorder well with 2 (two) screws where shown.
4. Reconnect remaining connectors by reversing steps 2 through 4 above.
5. Replace lower housing assembly per instructions on page VII-5.


MAIN CONTROL
PANEL
TIE WRAPS
HOT MELT

4. REMOVING THE MAIN CONTROL PANEL

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- X-Acto Knife

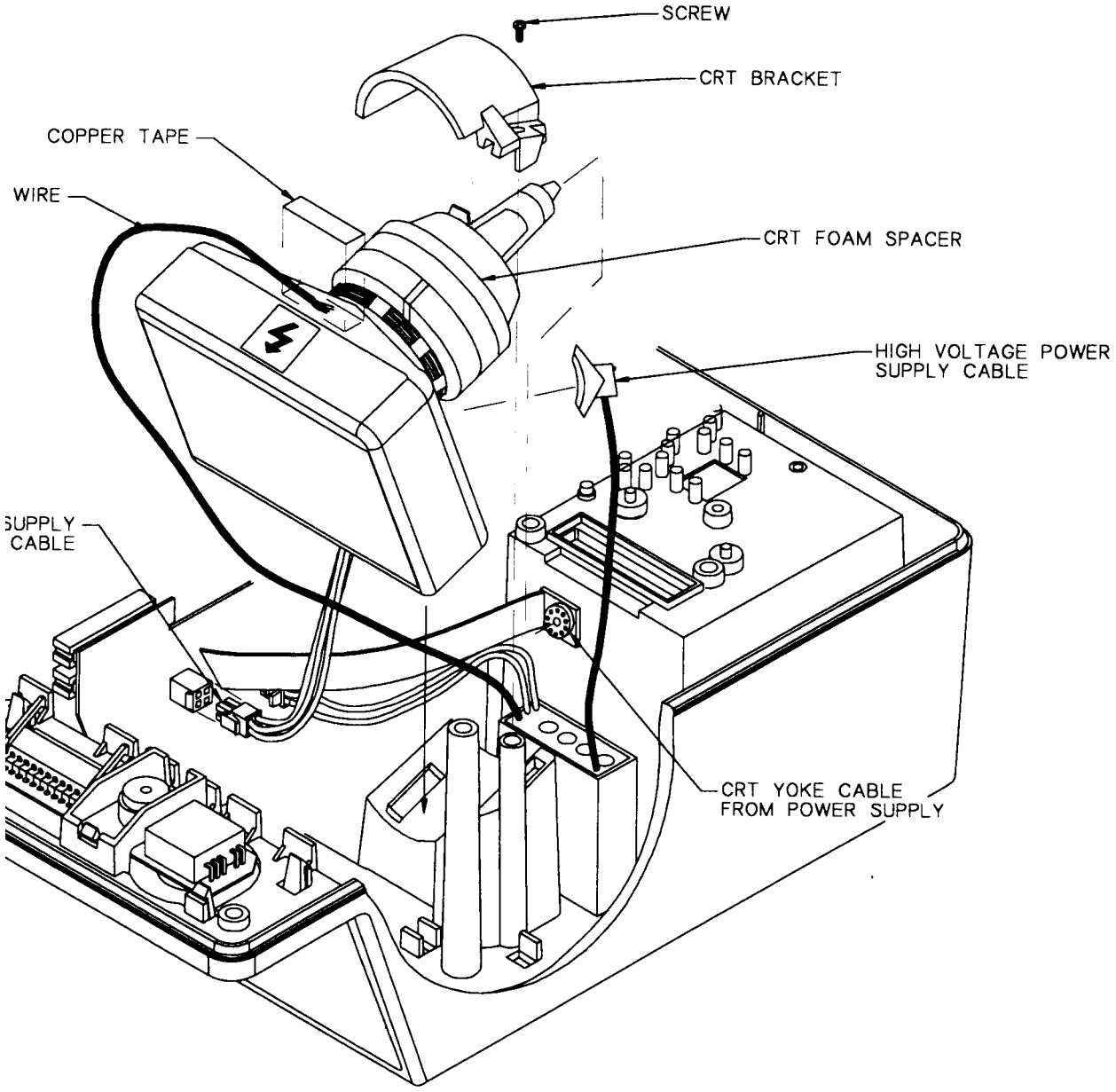
1. Remove the lower housing assembly as shown on page VII-5.
2. Disconnect main cable from main control PCB as shown on page VII-9, step 2.
3. Cut the tie wrap and hot melt (4 places) and release main control assembly snap hooks from the upper housing. **Do not cut the snap hooks.**
4. Push main control assembly out from inside the upper housing and remove.

STALLING THE MAIN CONTROL PANEL

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Tie wrap
- RTV or hot melt

1. Insert main control assembly into upper housing until latches secure the assembly to the upper housing. Install new tie-wrap (4 places) around the latches. Apply RTV or hot melt.
2. Reconnect main cable assembly to main control assembly as shown on page VII-9.
3. Replace lower housing assembly per instructions as shown on page VII-5.


SCREW
CRT BRACKET
COPPER TAPE
WIRE
CRT FOAM SPACER
HIGH VOLTAGE POWER
SUPPLY CABLE
SUPPLY
CABLE
CRT YOKE CABLE
FROM POWER SUPPLY

5. REMOVING THE CRT ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver

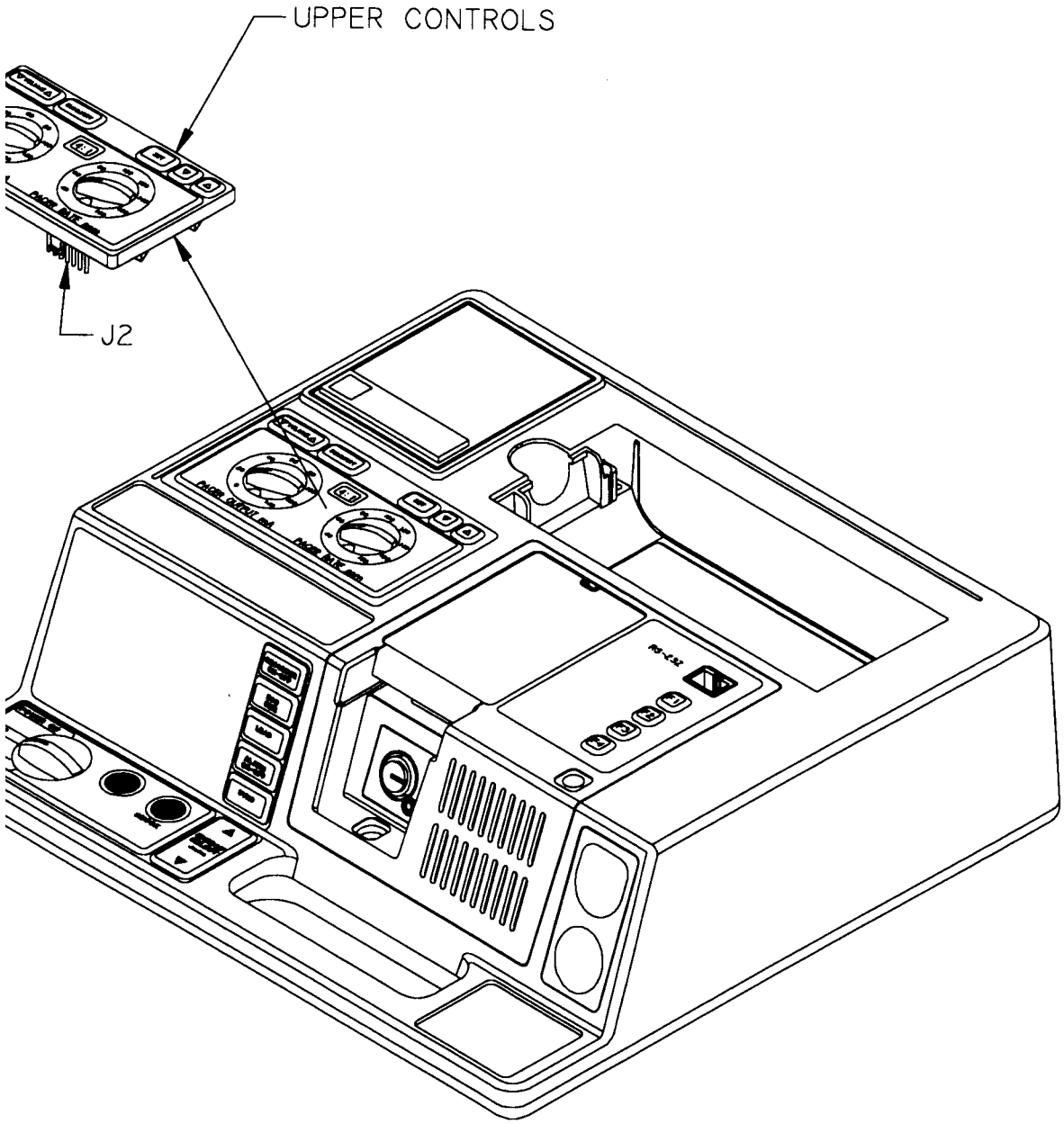
1. Remove the lower housing assembly as shown on page VII-5.
2. Remove main cable assembly as shown on page VII-9.
3. Remove copper tape on CRT to release the ground wire.
4. Remove the screw securing the CRT bracket.
5. Remove the foam spacer from the CRT yoke.
6. Remove the CRT as shown in the illustration:
    1. Push down at the back of the CRT.
    2. Tilt the CRT back away from the CRT window.
    3. Partially lift the CRT out of the unit.
7. Disconnect the high-voltage multiplier connector on the CRT. There are two metal clips inside the plastic shield securing the connector to the CRT monitor. Compress them together with a small flat blade screwdriver while pulling the connector away from the monitor.
8. Disconnect the flat cable from the power supply PCB at the end of the CRT.
9. Disconnect the cable from the CRT Yoke at the power supply PCB.
10. Remove the CRT from the unit.

ISTALLING THE CRT ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver

1. Reverse steps 3-10.
2. Reconnect main cable assembly to main control assembly as shown on page VII-9.
3. Replace lower housing assembly per instructions as shown on page VII-5.


UPPER CONTROLS
J2

6. REMOVING THE UPPER CONTROL ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver
- Needle nose pliers
- X-Acto Knife

1. Remove the lower housing assembly as shown on page VII-5.
2. Remove main cable connection at the main control PCB and digital PCB as shown on page VII-9.
3. Remove CRT as shown on page VII-13.
4. Disconnect display control flex cable from the upper control PCB. (See page VII-16)
5. Release upper control assembly snap hooks (cut hot melt as necessary) and carefully push assembly through the top of the upper housing.

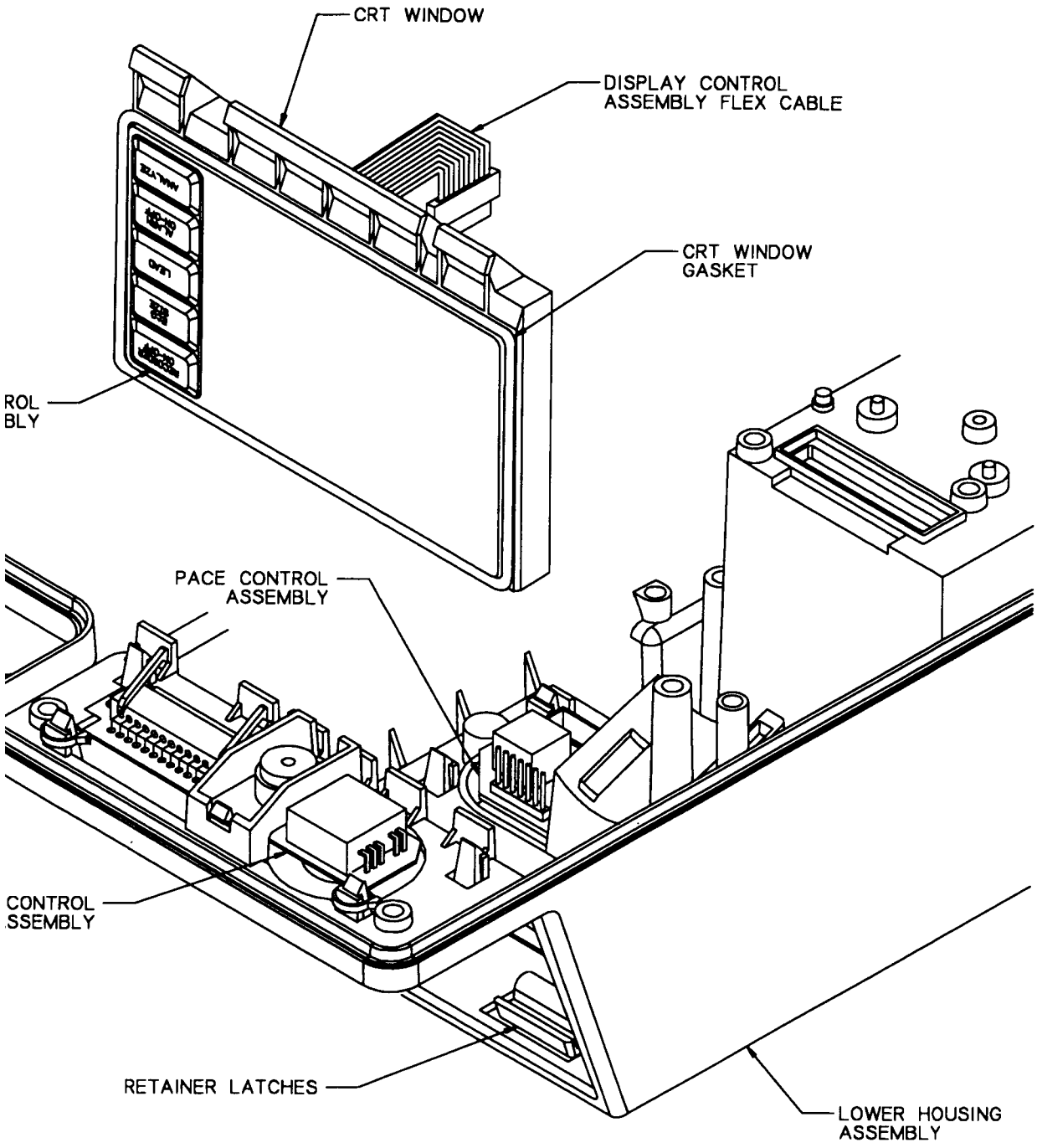
   Do not cut the retaining latches.

INSTALLING THE UPPER CONTROL ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver
- Needle nose pliers
- Hot melt

1. Insert upper control assembly until latches secure assembly to upper housing. Apply hot melt.
2. Connect display control flex cable to the upper control PCB.
3. Install CRT as shown on page VII-13.
4. Connect main cable to the main control PCB and digital PCB as shown on page VII-9.
5. Replace lower housing assembly as shown on page VII-5.


CRT WINDOW
DISPLAY CONTROL ASSEMBLY FLEX CABLE
CRT WINDOW GASKET
ROL
BLY
PACE CONTROL ASSEMBLY
CONTROL
SSEMBLY
RETAINER LATCHES
LOWER HOUSING ASSEMBLY

7. REMOVING THE CRT WINDOW

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver
- Needle nose pliers

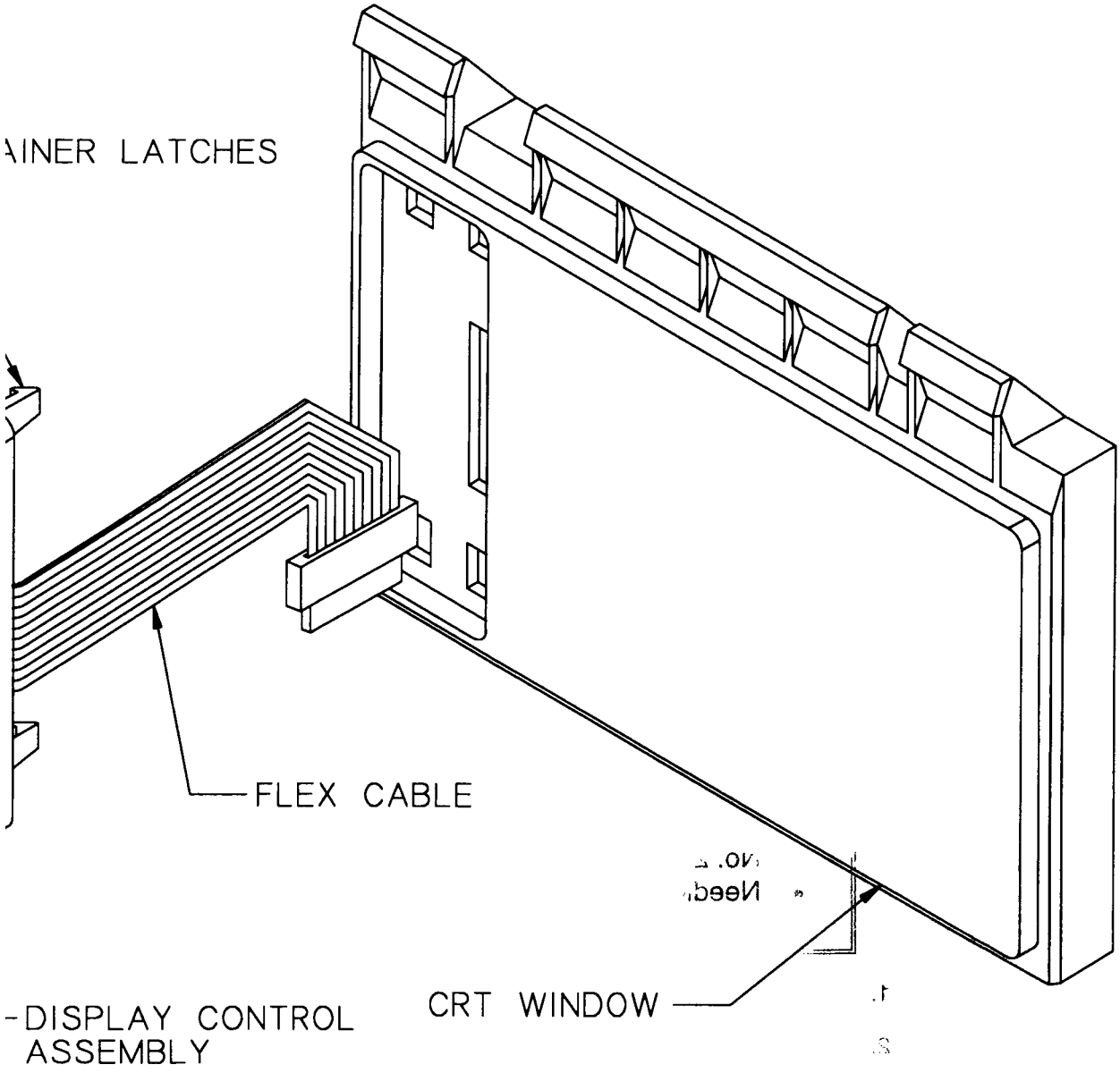
1. Remove the lower housing assembly as shown on page VII-5.
2. Remove the main cable connection at the main control and digital PCB shown on page VII-9.
3. Remove the CRT as shown on page VII-13.
4. Disconnect the display control flex cable from the upper control assembly.
5. Release CRT window from the upper housing by depressing the retaining latches in the direction of arrows on the illustration.
6. Remove CRT window and display control assembly from the unit.
7. Remove the display control assembly from the CRT window per instructions on page VII-19.
8. Remove the CRT window gasket from the CRT window.

STALLING THE CRT WINDOW

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver
- Needle nose pliers

1. Install a new CRT gasket onto the CRT window.
2. Install the display control assembly onto the CRT window as shown on page VII-19.
3. Insert CRT window into the upper housing ensuring that the latches have completely seated and secured the CRT window in the unit.
4. Reconnect the display control assembly flex cable to the upper control assembly.
5. Install CRT as shown on page VII-13.
6. Connect main cable to the main control PCB and digital PCB as shown on page VII-9.
7. Replace lower housing assembly as shown on page VII-5.


AINER LATCHES
FLEX CABLE
-DISPLAY CONTROL
ASSEMBLY
CRT WINDOW

8. REMOVING THE DISPLAY CONTROL ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

Note: It is not necessary to remove the CRT window from the upper housing to perform this operation. CRT window is shown removed for clarity.

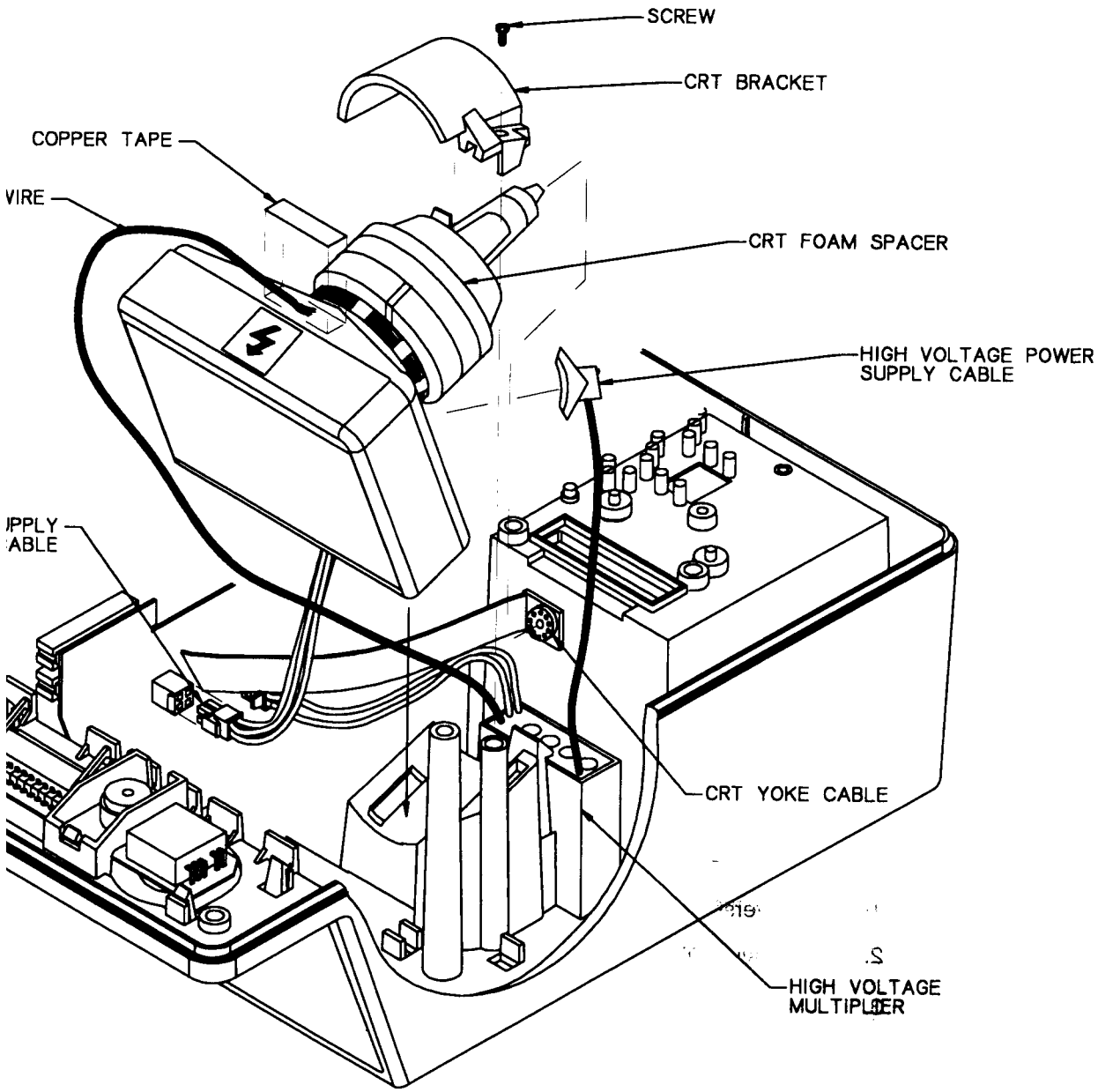
1. Remove lower housing assembly as shown on page VII-5.
2. Disconnect main cable from main control assembly as shown on page VII-9.
3. Disconnect display control assembly flex cable from upper control assembly.
4. Release the 4 (four) display control assembly retainer latches from rear of CRT window.
5. Remove display control assembly through front of CRT window.

ISTALLING THE DISPLAY CONTROL ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

1. Reverse steps 3 through 5 above.
2. Connect main cable to the main control PCB and the digital PCB as shown on page VII-9.
3. Replace lower housing assembly as shown on page VII-5.


SCREW
CRT BRACKET
COPPER TAPE
VIRE
CRT FOAM SPACER
HIGH VOLTAGE POWER
SUPPLY CABLE
IPPLY
ABLE
CRT YOKE CABLE
HIGH VOLTAGE
MULTIPLIER

9. REMOVING THE HIGH VOLTAGE MULTIPLIER ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver
- Needle nose pliers

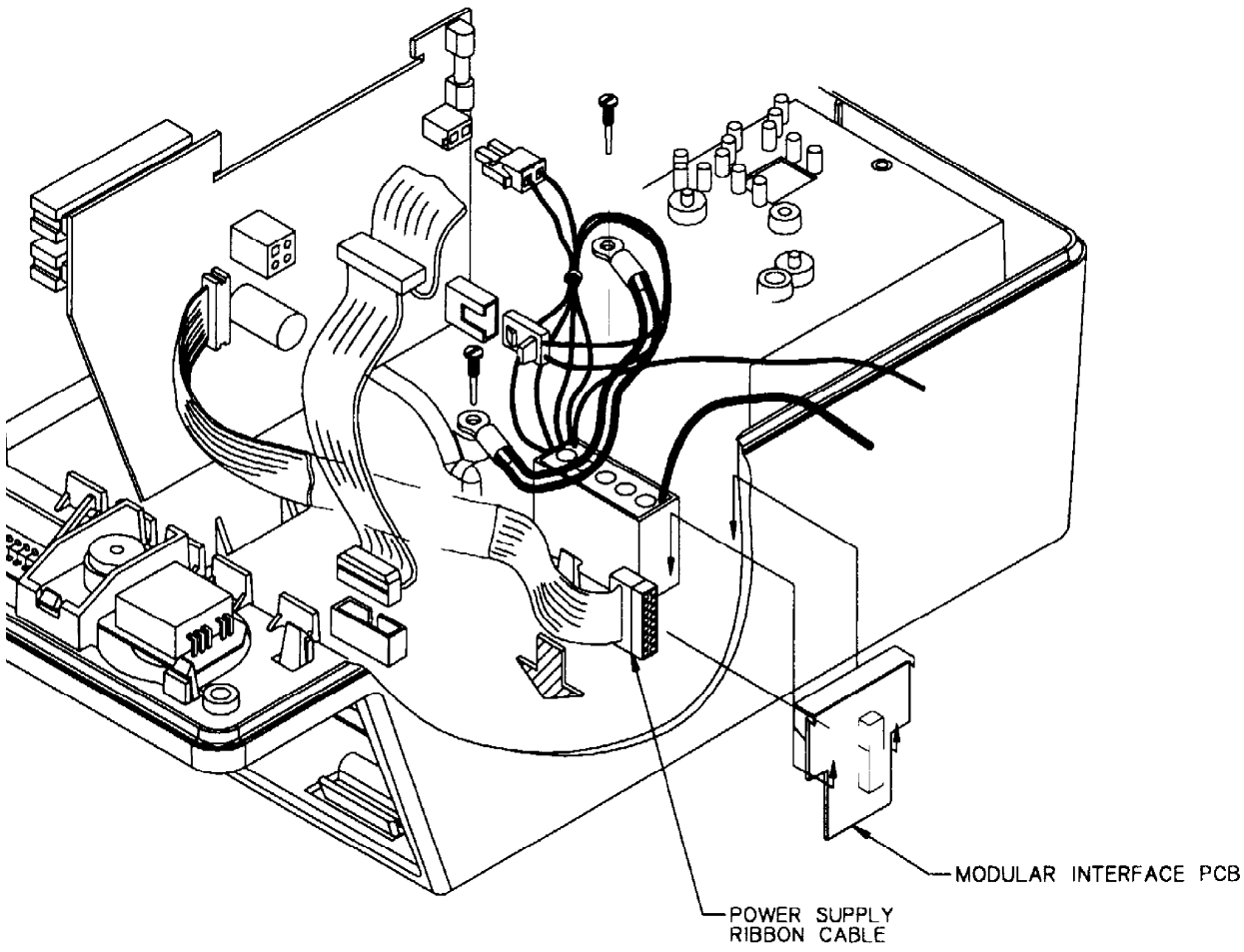
1. Remove the lower housing assembly as shown on page VII-5.
2. Remove the main cable connection at the main control and digital PCB shown on page VII-9.
3. Remove the CRT as shown on page VII-13.
4. Disconnect the high-voltage cable at the power supply PCB.
5. Release the clip holding the HV multiplier and remove from the unit.

INSTALLING THE HIGH VOLTAGE MULTIPLIER ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Small flat blade screwdriver
- Needle nose pliers

1. Reverse steps 4 & 5 above.
2. Install CRT as shown on page VII-13.
3. Connect main cable to the main control PCB and the digital PCB as shown on page VII-9.
4. Replace lower housing assembly as shown on page VII-5.


MODULAR INTERFACE PCB
POWER SUPPLY
RIBBON CABLE

10. REMOVING THE MODULE INTERFACE PCB ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

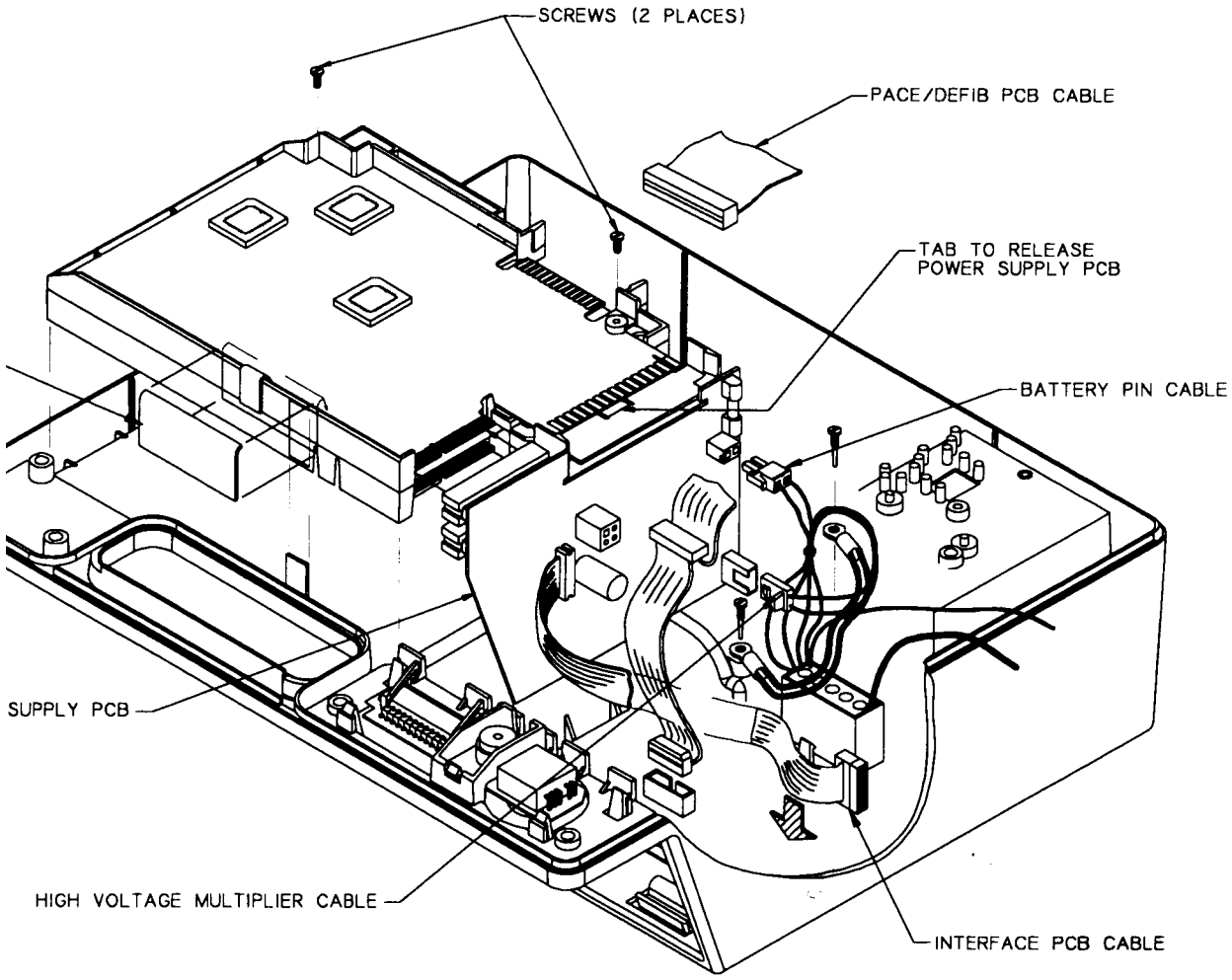
1. Remove the lower housing assembly as shown on page VII-5.
2. Lift module interface PCB assembly partially from unit.
3. Disconnect ribbon cable from power supply PCB.
4. Remove module interface PCB assembly.

ISTALLING THE MODULE INTERFACE PCB ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

1. Connect ribbon cable from power supply PCB.
2. Insert module interface PCB assembly as shown.
3. Install lower housing assembly as shown on page VII-5.


SCREWS (2 PLACES)
PACE/DEFIB PCB CABLE
TAB TO RELEASE
POWER SUPPLY PCB
BATTERY PIN CABLE
SUPPLY PCB
HIGH VOLTAGE MULTIPLIER CABLE
INTERFACE PCB CABLE

11. REMOVING THE POWER SUPPLY PCB ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers
- X-Acto Knife

Note: It is not necessary to remove the CRT window from the upper housing to perform this operation. CRT window is shown removed for clarity.

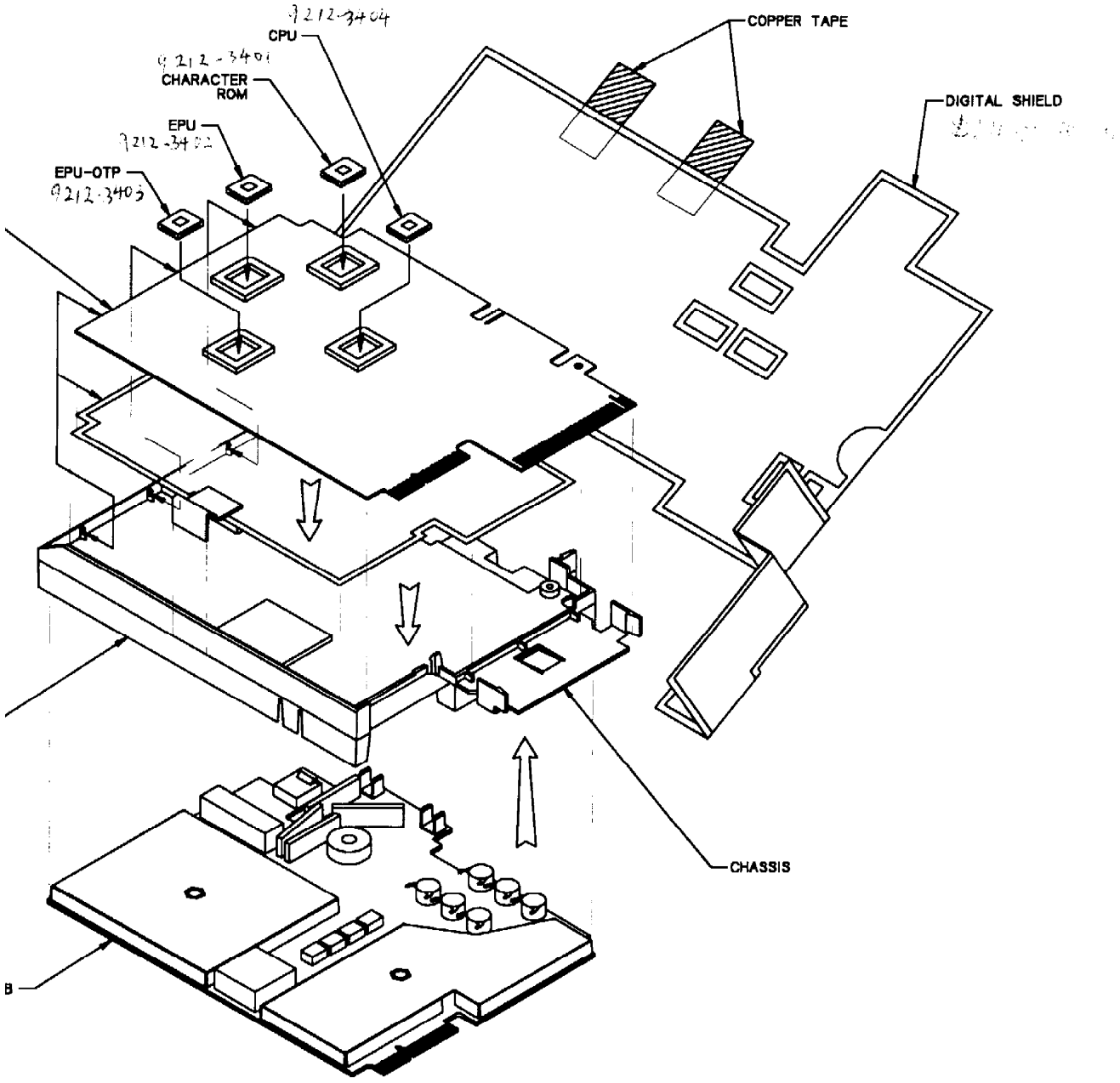
1. Remove the lower housing assembly as shown on page VII-5.
2. Disconnect the main cable connection at the main control and digital PCB as shown on page VII-9.
3. Disconnect the CRT yoke connector at CRT.
4. Disconnect the CRT/power supply cable connector at the power supply.
5. Disconnect the battery terminal/power supply connector at the power supply.
6. Disconnect 4 (four) leads from patient relay on rear of Analog board.
7. Disconnect pace/defib connector/digital board connector at rear of the digital board. The connector lock is located under the connector.
8. Disconnect the digital PCB/defib PCB connector at rear of the digital PCB.
9. Disconnect the ECG connector cable at the rear of the Analog PCB.
10. Remove the copper tape on the front of the chassis.
11. Cut tie wrap securing the wires at the rear of the chassis.
12. Lift PCB chassis partially out of the unit.
13. Disconnect HV multiplier/power supply PCB connector at power supply.
14. Disconnect the power supply/interface PCB connector at the interface PCB.
15. Lift the chassis out of the unit.
16. Unclip tab and remove the power supply PCB from the chassis.

STALLING THE DIGITAL POWER SUPPLY PCB ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers
- Tie wrap

1. Reverse steps 3-17.
2. Connect main cable to the main control PCB and the digital PCB as shown on page VII-9.
3. Replace lower housing assembly as shown on page VII-5.


CPU
CHARACTER ROM
EPU
EPU-OTP
COPPER TAPE
DIGITAL SHIELD
CHASSIS
B

12. DISASSEMBLY OF THE DIGITAL, ANALOG PCB CHASSIS

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

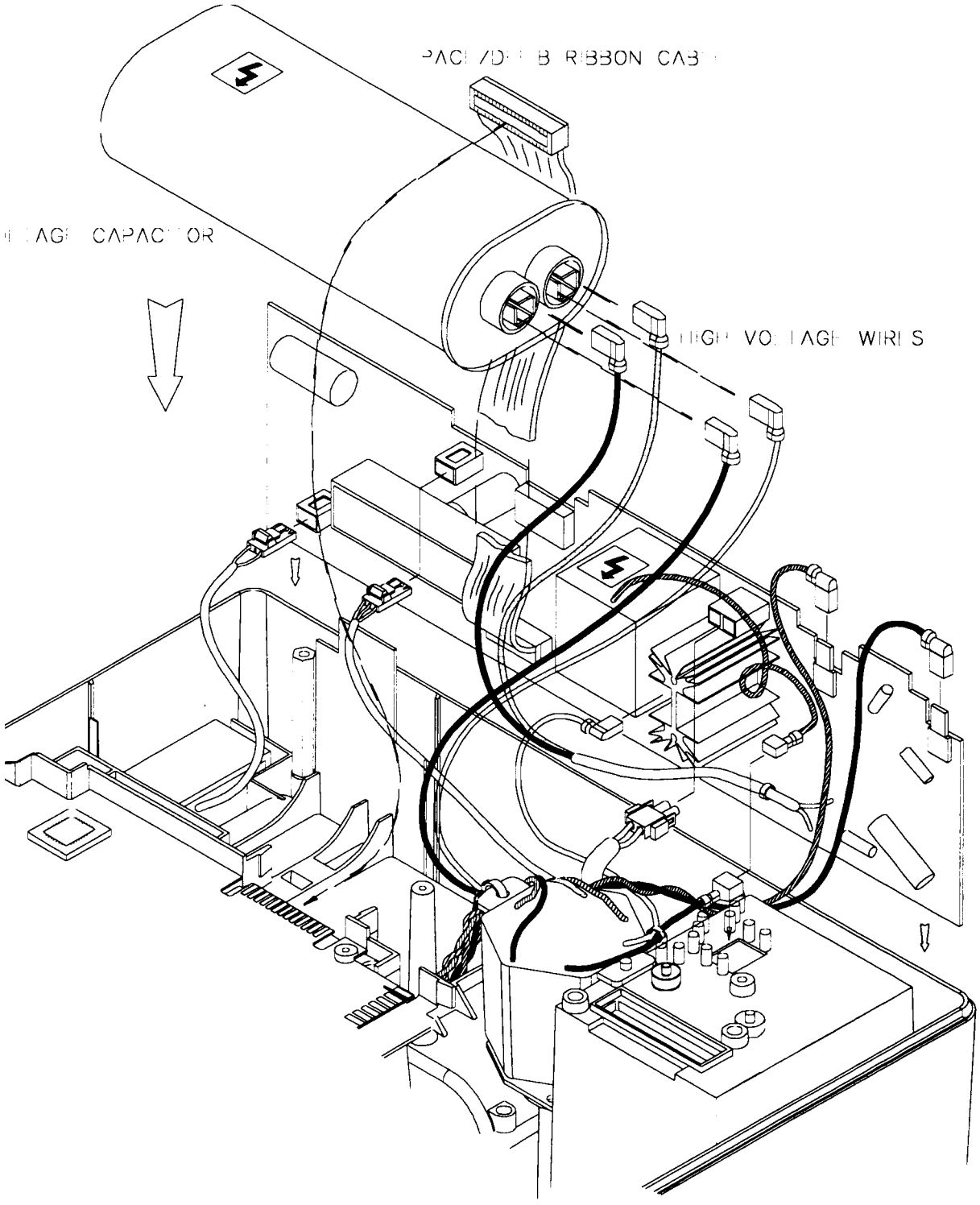
1. Remove the PCB chassis as shown on page VII-25.
2. To remove digital and Analog PCBs from the main board chassis release chassis clip on right side and remove.

SSEMBLY OF THE DIGITAL, ANALOG PCB CHASSIS

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

1. Assemble as shown in the illustration.
2. Replace the PCB chassis as shown on page VII-25.


PAC /D B RIBBON CAB
AGE CAPAC OR
IGH VO AGE WIRI S

13. REMOVING THE HIGH VOLTAGE CAPACITOR

WARNING

- COMPLETELY DISCHARGE HIGH VOLTAGE CAPACITOR BEFORE REMOVING FROM UNIT.
- DO NOT SHORT THE TERMINAL ENDS OF THE CAPACITOR.

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers
- Voltmeter & Resistors

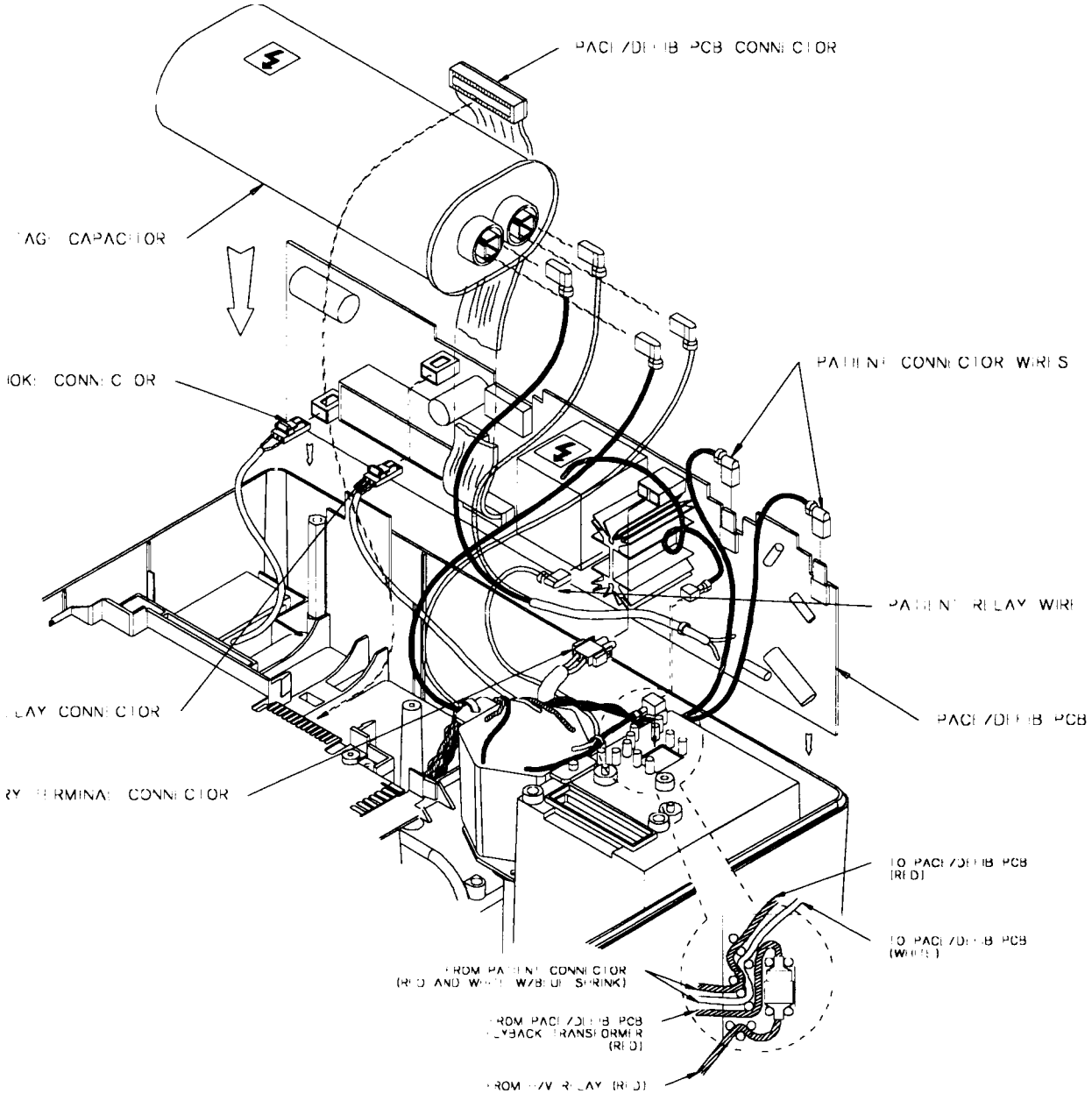
1. Remove the lower housing assembly as shown on page VII-5.
2. Disconnect pace/defib PCB ribbon cable from the digital PCB.
3. Measure the voltage of the capacitor with a voltmeter.
4. Use appropriate 5 watt resistor to bleed the excess voltage slowly and safely based on the voltmeter reading.
5. Partially remove the high voltage capacitor from the unit.
6. Disconnect the 4 high voltage wires from the high voltage capacitor.
7. Remove the capacitor from the unit.

STALLING THE HIGH VOLTAGE CAPACITOR

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

1. Connect the high voltage wires to the high voltage capacitor.
2. Place the high voltage capacitor, label side up, into the unit. Be sure not to pinch any wires under the capacitor.
3. Connect the pace/defib PCB ribbon cable to the digital PCB.
4. Install the lower housing assembly as shown on page VII-5.


PACE/DEFIB PCB CONNECTOR
PATIENT CONNECTOR WIRES
PATIENT RELAY WIRE
PACE/DEFIB PCB
TO PACE/DEFIB PCB (RED)
TO PACE/DEFIB PCB (WHITE)
FROM PATIENT CONNECTOR (RED AND W/BLUE SHRINK)
FROM PACE/DEFIB PCB FLYBACK TRANSFORMER (RED)

14. REMOVING THE DEFIB PCB

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

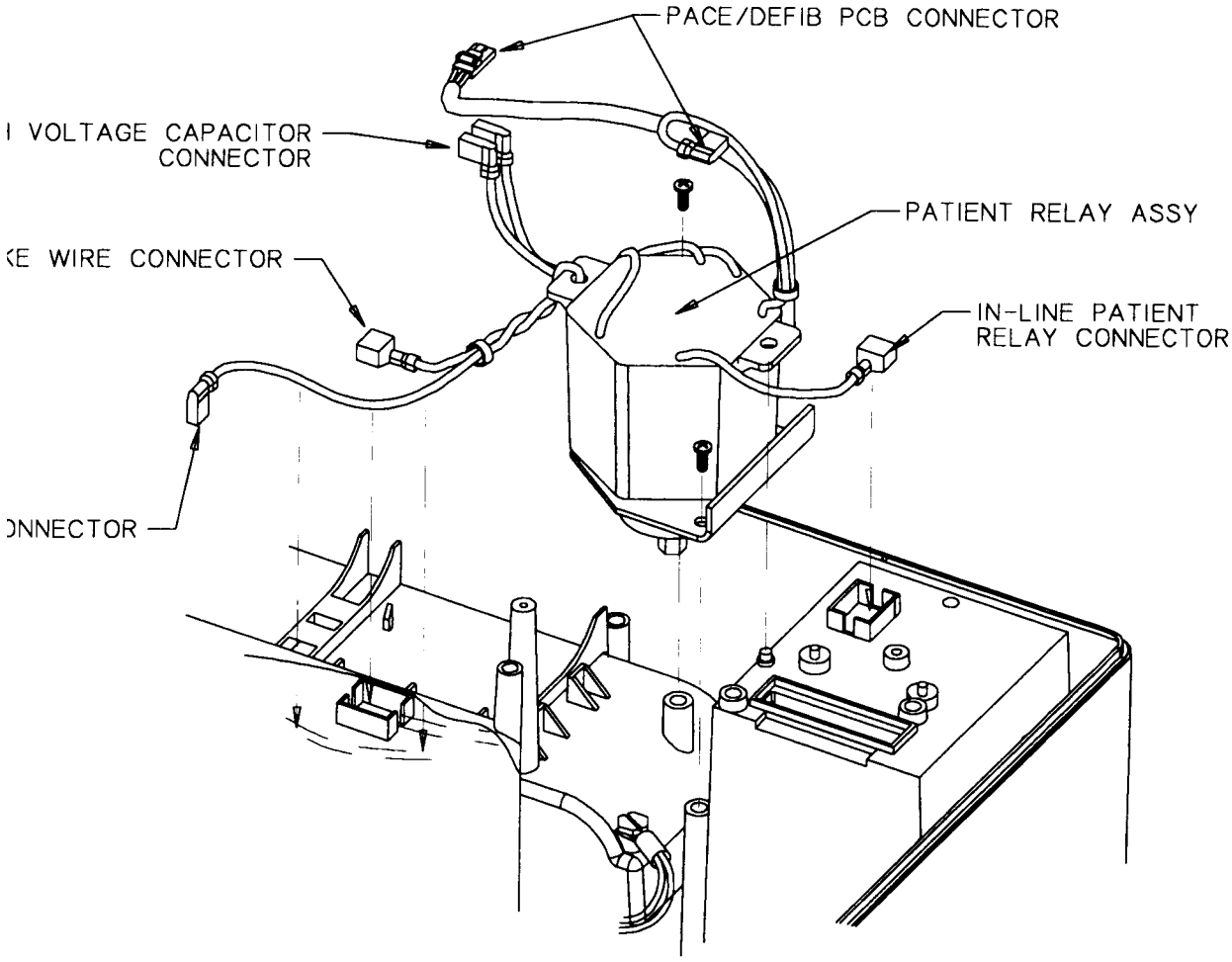
1. Remove the lower housing assembly as shown on page VII-5.
2. Remove the high-voltage capacitor as shown on page VII-29.
3. Disconnect pace/defib PCB ribbon cable from the digital PCB.
4. Disconnect the 4 (four) leads from the patient relay at the defib PCB.
5. Disconnect the battery terminal harness connector from the defib PCB.
6. Disconnect the choke connector at the defib PCB.
7. Partially lift the defib PCB out of the unit.
8. Disconnect the remaining lead from the patient relay.
9. Remove the defib PCB from the unit.

STALLING THE DEFIB PCB

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

1. Reverse steps 3 through 9 above.
2. Install the high-voltage capacitor as shown on page VII-29.
3. Install the lower housing assembly as shown on page VII-5.


PACE/DEFIB PCB CONNECTOR
I VOLTAGE CAPACITOR CONNECTOR
PATIENT RELAY ASSY
KE WIRE CONNECTOR
IN-LINE PATIENT RELAY CONNECTOR
ONNECTOR

15. REMOVING THE PATIENT RELAY ASSEMBLY

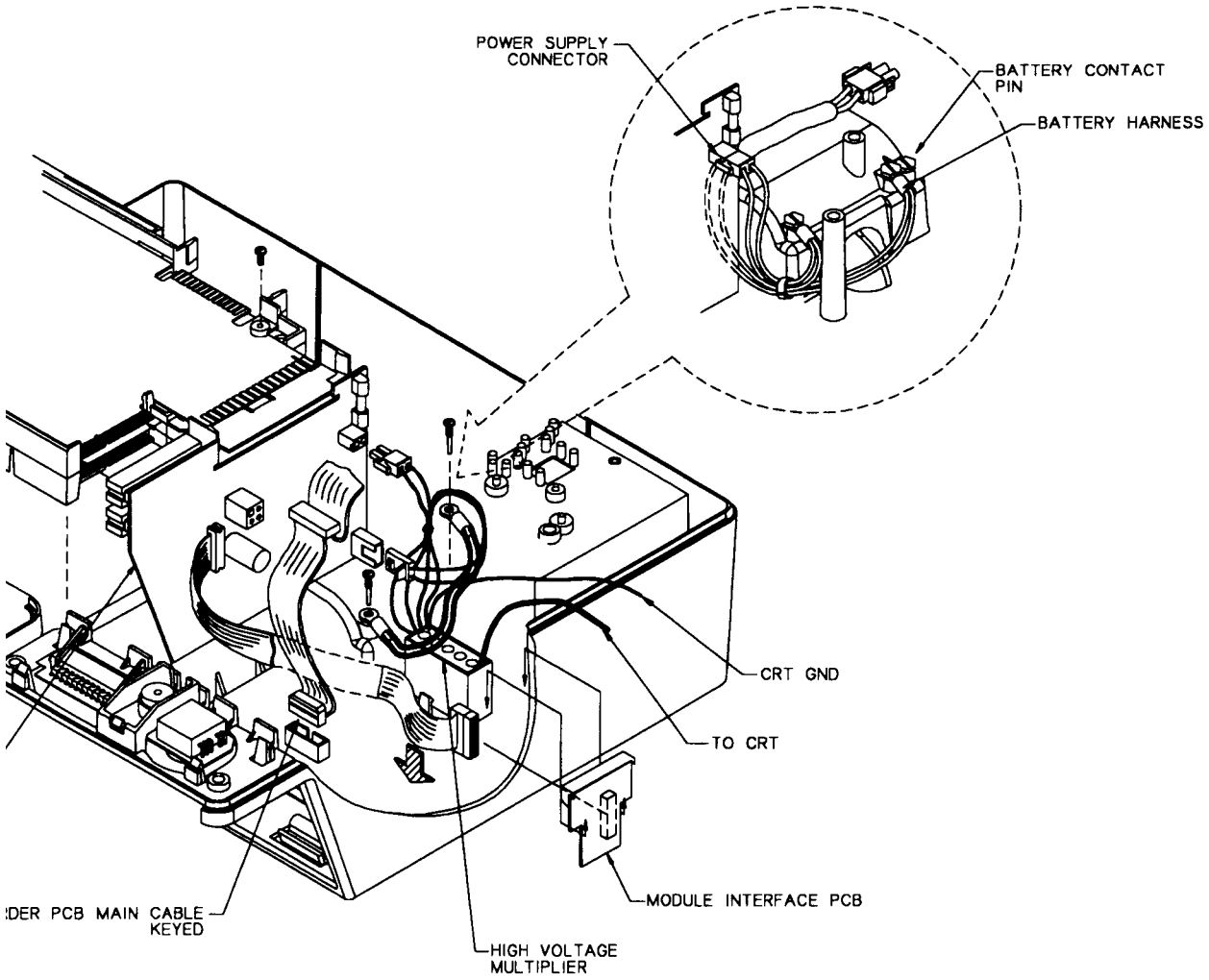
TOOLS REQUIRED:
- No. 2 Phillips head screwdriver
- Needle nose pliers

1. Remove the lower housing assembly as shown on page VII-5.
2. Remove main cable assembly as shown on page VII-9.
3. Remove the high-voltage capacitor as shown on page VII-29.
4. Partially remove the defib PCB from the unit as shown on page VII-31.
5. Disconnect the 2 (two) wires to pace/defib PCB.
6. Disconnect the in-line patient relay connector.
7. Disconnect the Analog connector at the rear of the Analog PCB.
8. Disconnect the choke wire at the in-line connector.
9. Remove the 2 (two) screws securing the patient relay bracket to the unit.
10. Lift patient relay out of unit.

ISTALLING THE PATIENT RELAY ASSEMBLY

TOOLS REQUIRED:
- No. 2 Phillips head screwdriver
- Needle nose pliers

1. Reverse steps 4 through 10 above.
2. Install the high-voltage capacitor as shown on page VII-29.
3. Install the main cable assembly as shown on page VII-9.
4. Install the lower housing assembly as shown on page VII-5.


POWER SUPPLY CONNECTOR
BATTERY CONTACT PIN
BATTERY HARNESS
CRT GND
TO CRT
MODULE INTERFACE PCB
:DER PCB MAIN CABLE KEYED
HIGH VOLTAGE MULTIPLIER

16. REMOVING THE BATTERY TERMINAL HARNESS, PIN ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers
- Regular screwdriver

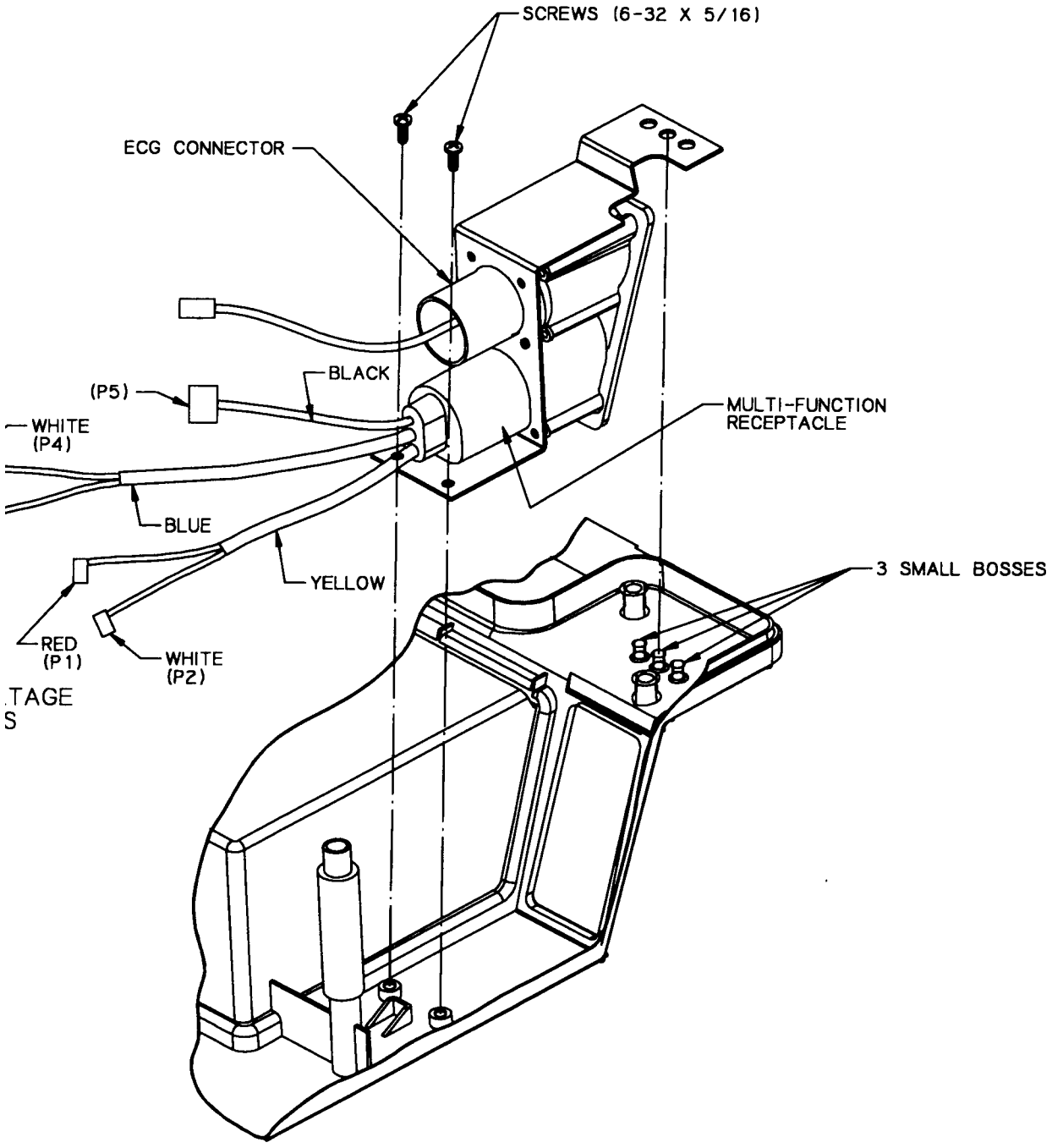
1. Remove the lower housing assembly as shown on page VII-5.
2. Remove main cable assembly as shown on page VII-9.
3. Remove the high-voltage capacitor as shown on page VII-29.
4. Remove the patient relay as shown on page VII-33.
5. Disconnect the power supply connector at the power supply PCB.
6. Disconnect the pace/defib PCB connector at the pace/defib PCB.
7. Remove the 2 (two) battery contact pins securing the battery harness to the unit.

STALLING THE BATTERY TERMINAL HARNESS, PIN ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers
- Regular screwdriver

1. Reverse steps 5 through 7 above. Install the red wire to the rear battery contact pin and the black wire to the front battery contact pin.
2. Install the patient relay as shown on page VII-33
3. Install the high-voltage capacitor as shown on page VII-29.
4. Install the main cable assembly as shown on page VII-9.
5. Install the lower housing assembly as shown on page VII-5.


SCREWS (6-32 X 5/16)
ECG CONNECTOR
BLACK
(P5)
WHITE
(P4)
MULTI-FUNCTION
RECEPTACLE
BLUE
YELLOW
3 SMALL BOSSES
RED
(P1)
WHITE
(P2)
.TAGE
S

17. REMOVING THE PATIENT CONNECTOR PANEL ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Needle nose pliers

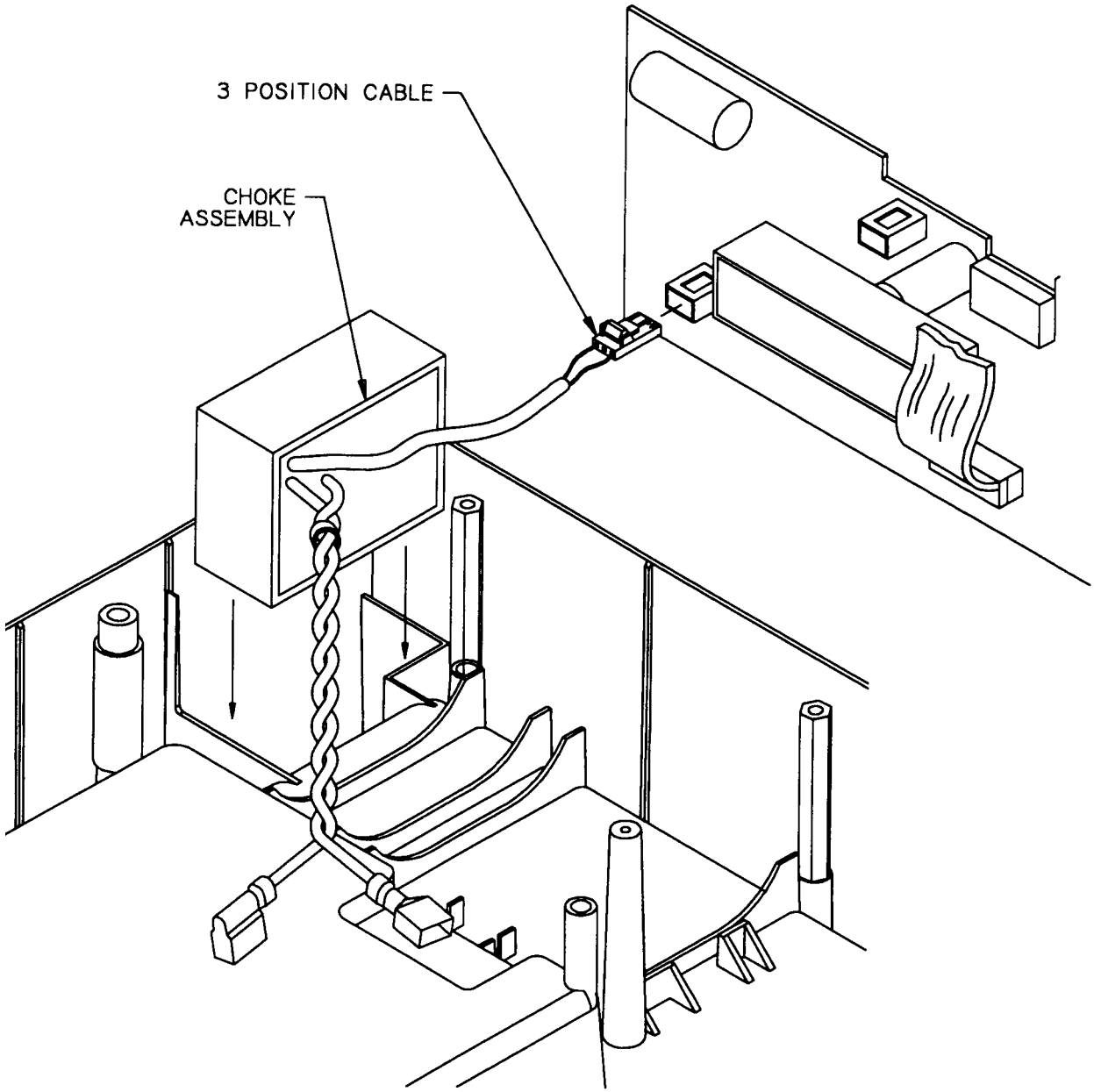
1. Remove the Lower Housing Assembly as shown on page VII-5.
2. Disconnect the cable that leads from the ECG connector from the Analog Advisory PCB.
3. Disconnect the black cable (labeled P5, leading from the Multi-Function Receptacle) from the Digital PCB.
4. Cut and remove the cable tie that secures high voltage wires to the chassis, taking care not to cut or nick any of the wires.
5. Disconnect the high voltage wires (labeled P1 and P2, part of the yellow cable that leads from the Multi-Function Receptacle) from the terminals on the Analog Advisory PCB.
6. Disconnect the high voltage wires (labeled P3 and P4, part of the blue cable that leads from the Multi-Function Receptacle) from the terminals on the Pace/Defib PCB.
7. Carefully free the black, yellow, and blue cables that lead from the Multi-Function Receptacle from their routing through the main assembly, taking care not to disturb other components.
8. Remove the two 6-32 x 5/16 screws that secure the Patient Connector Panel Bracket to the Upper Housing. Note that one of these screws also secures a ring terminal on the ground wire from the Digital Shield.
9. Lift the Patient Connector Panel Assembly out of the Upper Housing Assembly.

STALLING THE PATIENT CONNECTOR PANEL ASSEMBLY

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

1. Place the Patient Connector Panel Assembly into position in the Upper Housing, so that the face of the Patient Connector Panel projects through the opening in front of the Upper Housing and the three small bosses on the Upper Housing project through the holes in the metal bracket.
2. Fasten the metal bracket to the Upper Housing with two 6-32 x 5/16 screws; use the innermost screw to also secure the ring terminal on the ground wire from the Digital Shield.
3. Reverse steps 1 through 7, above, taking care that each cable is properly routed and connected to the proper terminals.


3 POSITION CABLE
CHOKE ASSEMBLY

18. REMOVING THE CHOKE

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- X-Acto Knife

1. Remove the lower housing assembly as shown on page VII-5.
2. Remove the high-voltage capacitor as shown on page VII-29.
3. Remove the screw securing the choke retainer.
4. Remove the choke retainer.
5. Cut tie wrap securing the wires to the PCB chassis.
6. Disconnect the wire connected to the Analog PCB.
7. Disconnect the wire connected inline to the patient relay.
8. Disconnect the cable connected to the pace/defib PCB.
9. Lift the choke out of the upper housing by pulling straight up.

STALLING THE CHOKE

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver
- Tie wrap

1. Reverse steps 3-9
2. Install the high-voltage capacitor as shown on page VII-29.
3. Install the lower housing assembly as shown on page VII-5.

19. REMOVING THE MRM MODULE

TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

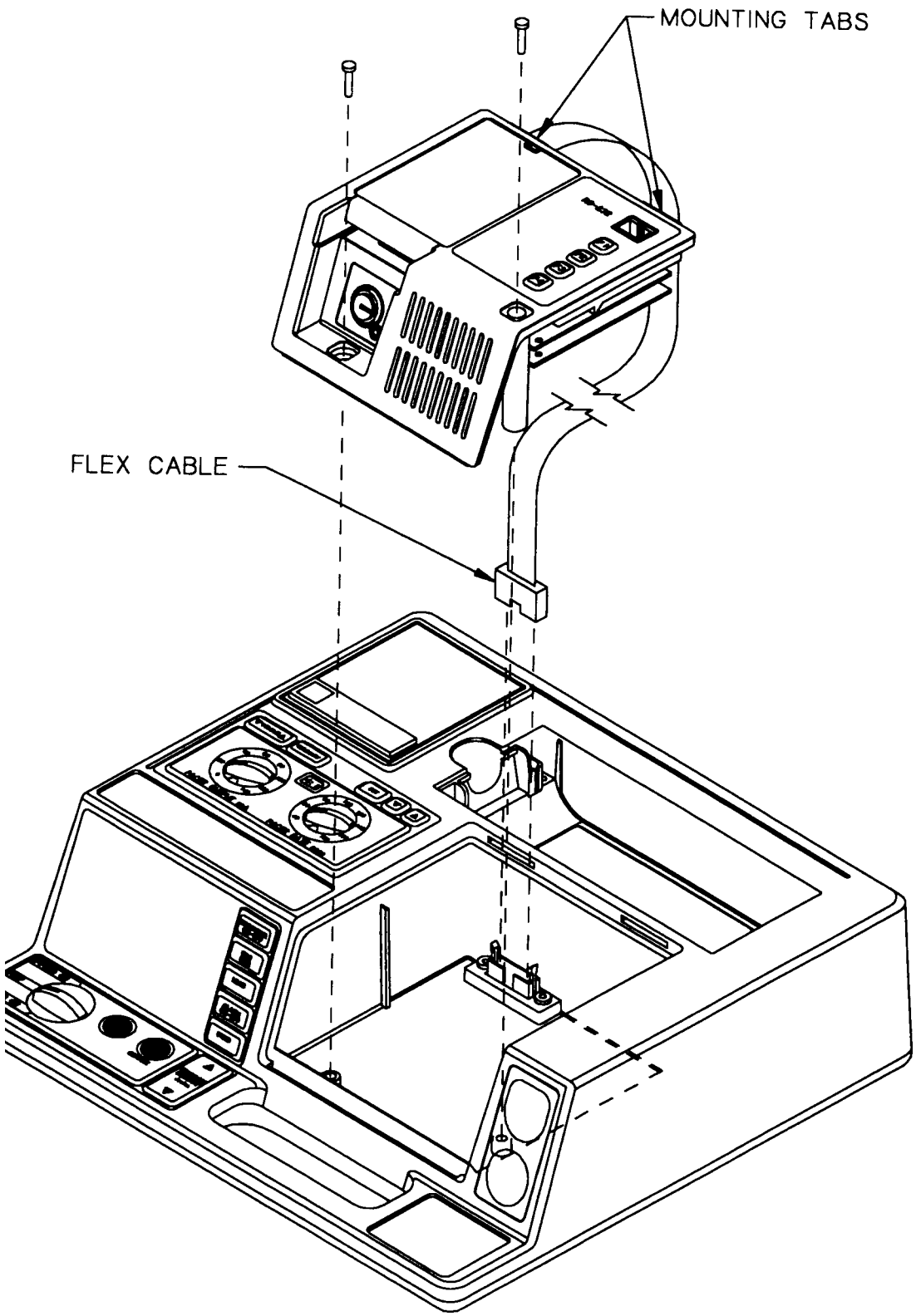
1. Remove labels and 2 (two) 5/16 screws as shown in illustration on page VII-40.
2. Lift MRM straight up and disconnect flex cable from the receptacle attached to the ZOLL 1600. (refer to page VII-40)
3. Disconnect speaker cable assembly from MRM main board section-I. (refer to page VII-41)
4. Disconnect keyswitch cable from receptacle on MRM board section-II and receptacles located on the keyswitch/speaker panel assembly. (page VII-41)
5. Remove 2 (two) screws 4-40 x 3/4" from self-retaining spacers located on the MRM main board section-II. (refer to page VII-42)
6. Unplug connector of functions keypad plug from receptacle located on the MRM main board section-II. (page VII-42)
7. Disconnect J1 connector on MRM main board section-II from J2 connector on MRM board section-I. (page VII-42)
8. Remove MRM main board section-I by disconnecting the 4-pin connector on the MRM main board section-I from the communications connector PCB. (shown in the illustration on page VII-43)
9. Remove the communications connector PCB by removing 2 (two) screws 4-40 x 1/4" shown in the illustration on page VII-44. Lift straight out.
10. Remove 3 (three) screws 4-40 x 1/4" from the keyswitch/speaker panel assembly. Lift the keyswitch/speaker panel assembly straight out.
11. Remove the speaker assembly by lifting straight out.

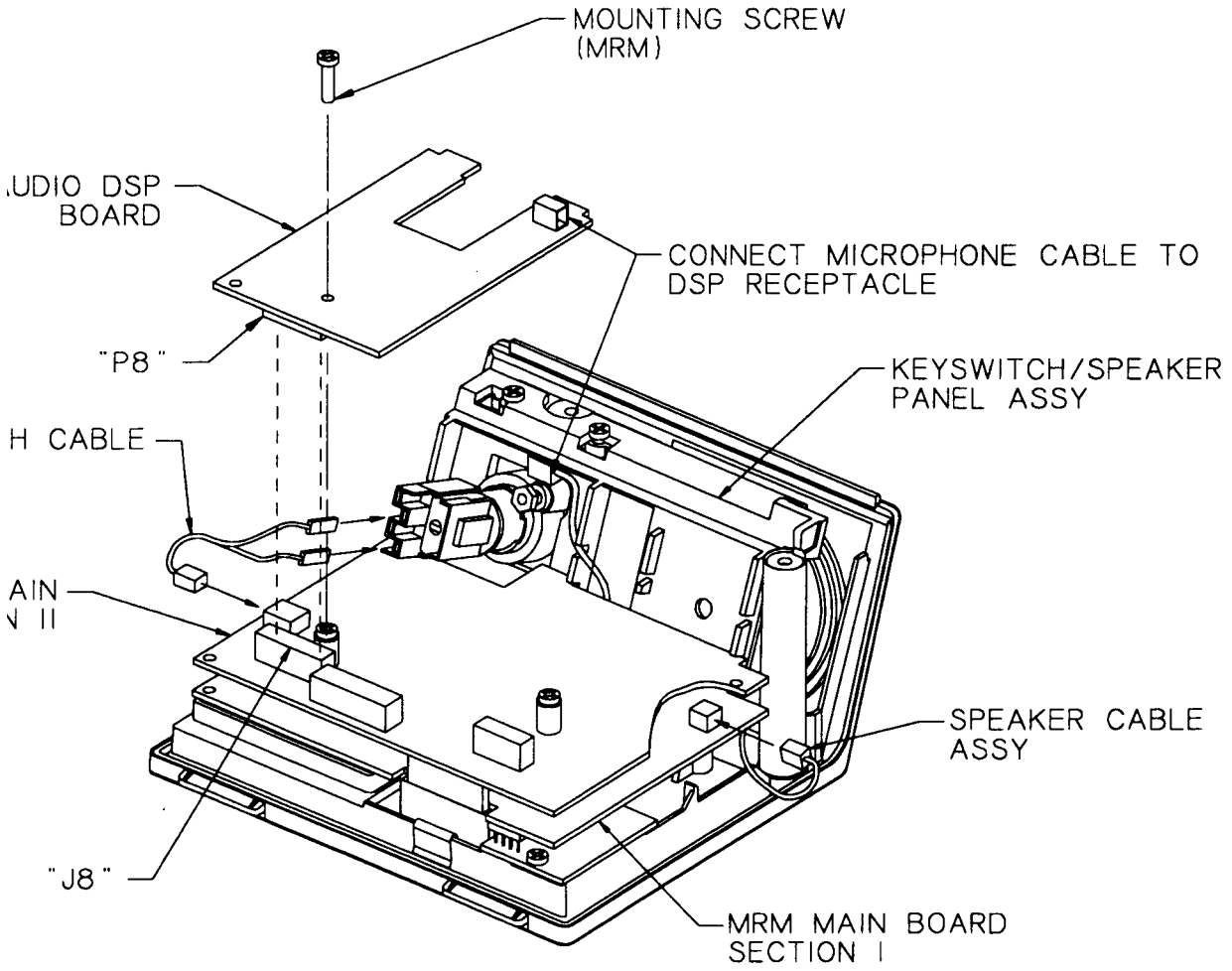
STALLING THE MRM MODULE

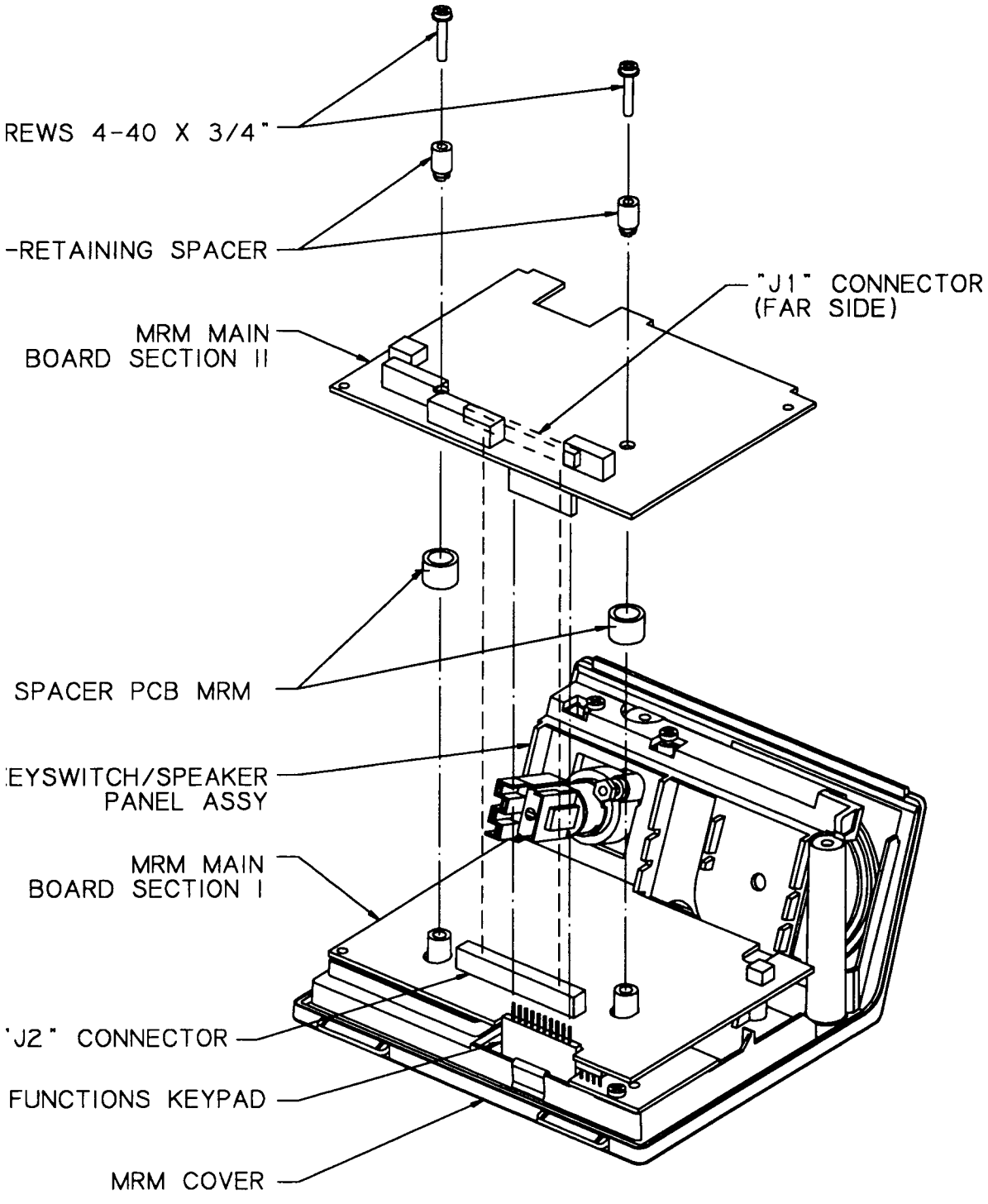
TOOLS REQUIRED:

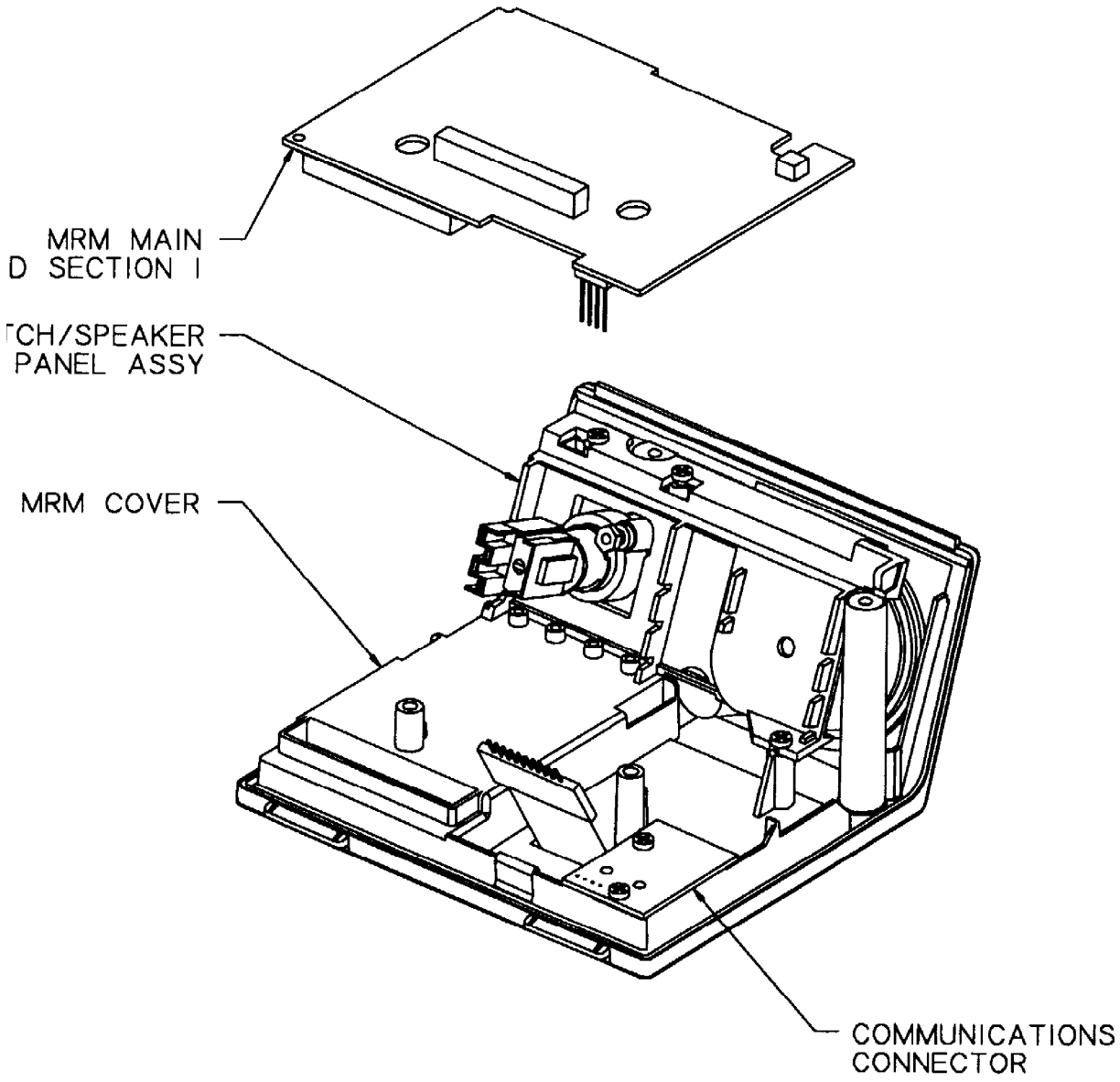
- No. 2 Phillips head screwdriver

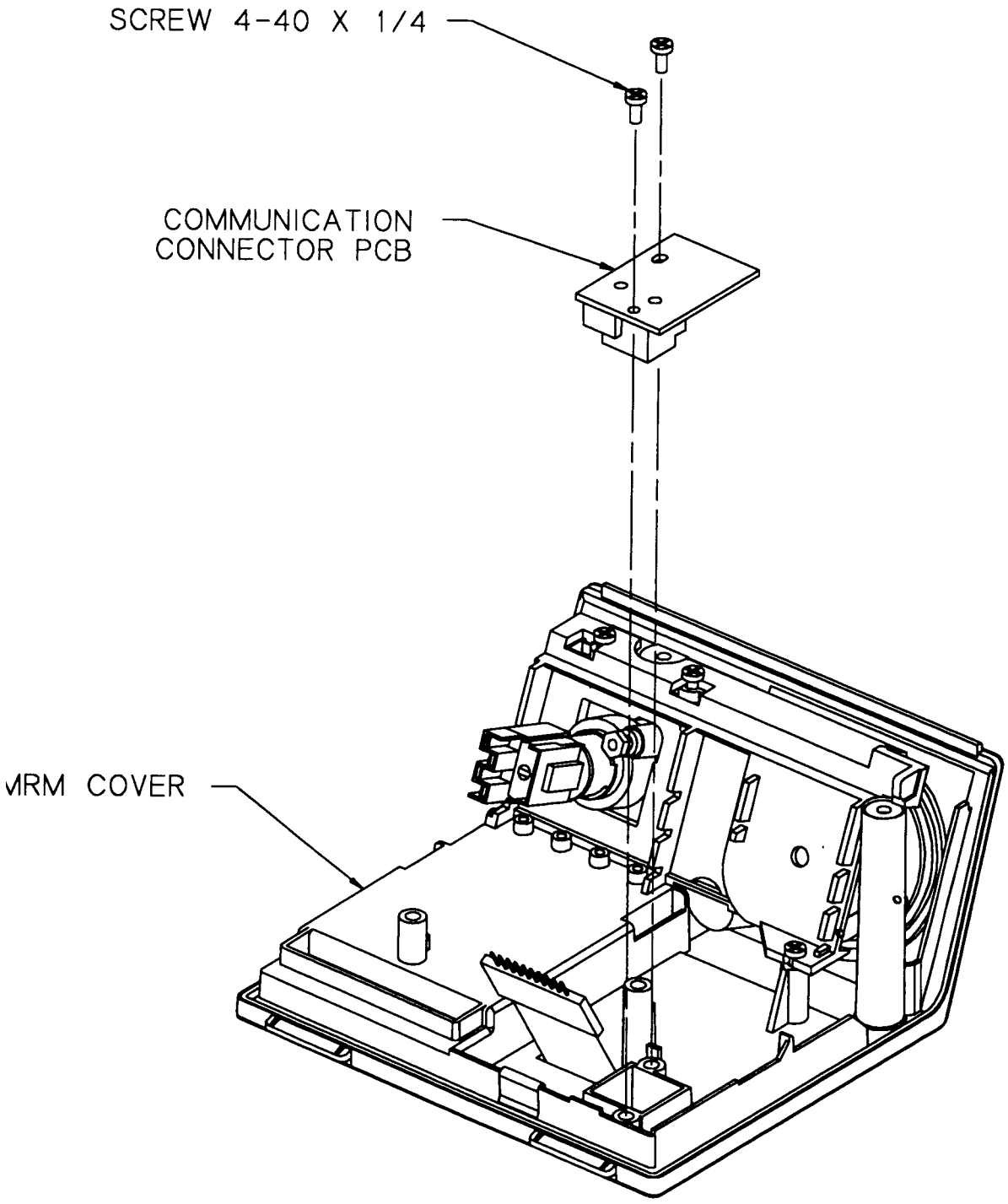
1. Reverse steps 1-11

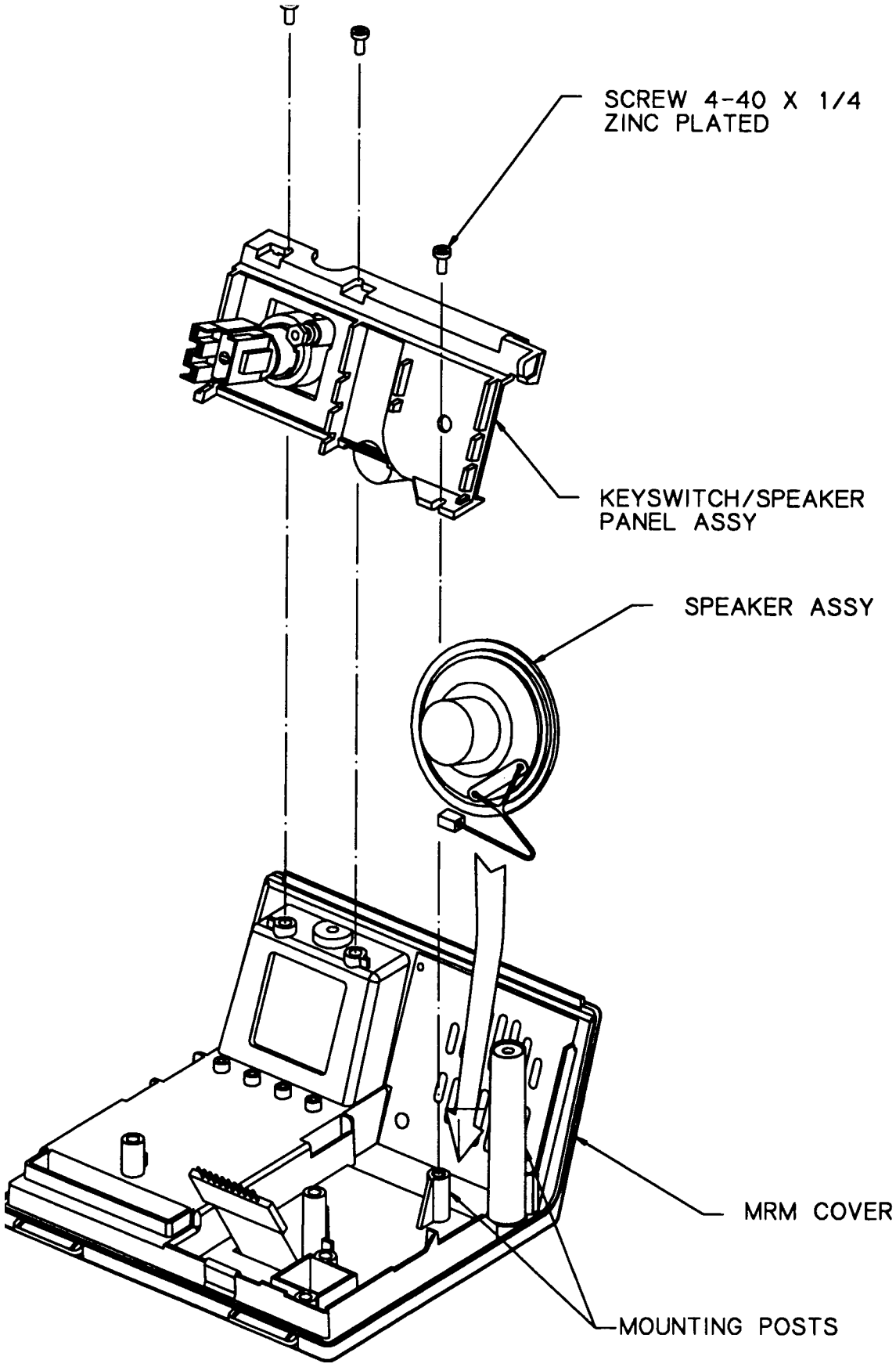

MOUNTING TABS
FLEX CABLE


MOUNTING SCREW
(MRM)
UDIO DSP
BOARD
CONNECT MICROPHONE CABLE TO
DSP RECEPTACLE
"P8"
KEYSWITCH/SPEAKER
PANEL ASSY
H CABLE
AIN
SPEAKER CABLE
ASSY
"J8"
MRM MAIN BOARD
SECTION I


REWS 4-40 X 3/4"
-RETAINING SPACER
MRM MAIN
BOARD SECTION II
"J1" CONNECTOR
(FAR SIDE)
SPACER PCB MRM
EYSWITCH/SPEAKER
PANEL ASSY
MRM MAIN
BOARD SECTION I
"J2" CONNECTOR
FUNCTIONS KEYPAD
MRM COVER


MRM MAIN
D SECTION I
TCH/SPEAKER
PANEL ASSY
MRM COVER
COMMUNICATIONS
CONNECTOR


SCREW 4-40 X 1/4
COMMUNICATION
CONNECTOR PCB
MRM COVER


SCREW 4-40 X 1/4
ZINC PLATED
KEYSWITCH/SPEAKER
PANEL ASSY
SPEAKER ASSY
MRM COVER
MOUNTING POSTS

SECTION VIII
REPLACEMENT PARTS

s section contains a listing of the replacement parts available for the ZOLL 1600 devices.

ɔlacement parts may be ordered through your sales representative, distributor, or directly from LL Medical Corporation. When ordering parts, please provide the following information:

- the ZOLL 1600 device's model and serial number
- the MRM serial number
- Field Replaceable Unit part number
- Description of the replacement part

ZOLL reserves the right to substitute different parts to reflect modifications and improvements in ZOLL 1600-series circuitry and design.

ɔrder directly from ZOLL Medical Corporation, address your request to:

ZOLL Medical Corporation	Telephone	(800) 348-9011
32 Second Avenue		(781) 229-0020
Burlington, MA. 01803	FAX	(781) 272-5578
Attention: Technical Service Department		

rent replacement part pricing is available from your sales representative or distributor. You ı also contact ZOLL's Technical Service Department for price quotations.

FIELD REPLACEABLE UNITS

scription		Part Number
Lower housing assembly		1004-0121
Printer/Recorder	ZOLL 1600 Paramedic,Advanced, Intermed.	9350-0040
Filler Kit, Recorder Well	ZOLL 1600 Basic	1006-0054
Main Cable Assembly		1006-0063
Main Control Assy (Pace/Defib)	ZOLL 1600 Paramedic	1006-0010
Main Control Assy (Non-Pacing)	ZOLL 1600 Advanced,Intermediate, Basic	1006-0015
CRT/Yoke Assembly		1004-0080
Upper Control Assy (Pace/Defib)	ZOLL 1600 Paramedic	1006-0017
Upper Control Assy (Non-Pace)	ZOLL 1600 Advanced,Intermediate, Basic	1006-0018
CRT Window		9310-0274
Display Control Assembly	ZOLL 1600 Paramedic,Advanced	1006-0011
Display Control Assembly (Single Function)	ZOLL 1600 Intermediate,Basic	1006-0020
High Voltage Multiplier Assembly		9301-0104
Module Interface PCB Assembly		9301-0106
Power Supply PCB Assembly		9301-0062
Digital PCB Assembly		9301-0138-02
Assy, PCB, Analog w/ Impedance Circuit		9301-0136
High Voltage Capacitor Assembly		1006-0047
Pace/Defib PCB Assembly		9301-0142
Patient Relay Assembly		1004-0019
Battery Harness Assembly		9500-0203
Battery Contact Pin		9330-0100
Patient Connector Panel Assembly		1006-0012
Choke Assembly		9140-0050
Medical Reporting Module (MRM)	ZOLL 1600 Paramedic,Advanced	1006-0002
Medical Reporting Module (MRM)	ZOLL 1600 Intermediate,Basic	1006-0030
MRM Main Board Section - I, PCBA		9301-0204
MRM Main Board Section - II, PCBA		9301-0205
MRM cover		1006-0003
Memory Card Cover Assembly		1006-0026
Communications Connector, PCBA		9301-0208

. Keyswitch/Speaker Panel Assembly 1006-0025
. Speaker Assembly 1006-0007
. Keyswitch Cable 9500-0112
. Label, Blank 0550-0031
. Label Set, Main 9305-0112-01
Label Set, Specification 9305-0240-01
Label, Serial Number 9305-0058
Label Set, Screw Cover 9305-0101
Label Set, MRM Cover 9305-0096-01
Screw, Sem w/ ext., 6-32 x 5/16" 0163-0911
Charger Port Connector 9301-0027
Charger Port Membrane 9330-0074
Multifunction Cable 8000-1601
Upper Housing w/Conductive Coating 9310-0107
Display Control Boot 9310-0059-01
Key Switch Assembly 0170-0009
Multifunction Cable O-Ring 0310-0312

functions keypad for MRM 9170-0015

Digital board - Shield 9330-0113

w/Defib PCB Assy 9301-0061

APPENDIX A

CALIBRATION / ADJUSTMENT PROCEDURE

&

MANUFACTURING CONFIGURATION PROCEDURE

The following **Calibration/Adjustment Procedure** must be performed any time a module is replaced in the ZOLL 1600. This section allows properly trained service technicians to check and adjust the **Intensity Calibration, the X-Axis Calibration, the Y-Axis Calibration, and the Impedance Measurement** of the ZOLL 1600.

In addition, if the Digital or MRM boards are replaced, the **Manufacturing Configuration Procedure** explains how to program the System and Medical Reporting Module (MRM) serial numbers into the ZOLL 1600.

alibration / Adjustment **A-2**

a. Intensity Calibration **A-2**

b. X-Axis Calibration **A-2**

c. Y-Axis Calibration **A-3**

d. Impedance Calibration **A-3**

anufacturing Configuration Procedure **A-4**

a. System Serial Number Procedure **A-4**

b. MRM Serial Number Procedure **A-4**

1. CALIBRATION / ADJUSTMENT

ETUP

- Install battery.
- Plug MFE cable into the ZOLL 1600 and connect to the S-3000 Simulator or equivalent.
- Plug the ECG cable into the ZOLL 1600 and connect leads to the S-3000 Simulator.

NTER DIAGNOSTICS MODE

To power up the ZOLL 1600 in diagnostics mode:

- Press and hold the **SYNC** button for at least 7-10 seconds (until 5 beeps total are heard) while turning the **SELECTOR SWITCH** to **POWER ON**.
- The battery voltage will be displayed on CRT as "XXXV" (for example, "100V", which means 10.0 volts).

NTER DEEP DIAGNOSTIC MODE

- Press and hold the **VOL** up (▲) arrow button and the **SET** down (▼) arrow buttons for 5-8 seconds. A two beep signal will indicate that the unit is in deep diagnostics mode. The letter "D" will appear on the display preceding the battery voltage.

ITENSITY CALIBRATION TEST PROCEDURE (D1)

- Press the **SET** button to enter the CRT Intensity Calibration mode.
- Turn the Manual Key clockwise (to 3 o'clock position) and release.
- Turn the key clockwise (to 3 o'clock position) again within 5 seconds to confirm **Manual Mode** Operation.
- Set **LEAD** to I and **ECG SIZE** to 3X.
- Set the S-3000 Simulator to a normal sinus rhythm : BPM =120
- Press **SYNC** button.
- Adjust the intensity of the CRT using the **ENERGY SELECT** up (▲) and down (▼) arrows until there is a distinct difference between the SYNC markers on the waveform and the actual ECG signal.

NOTE: The nominal value for intensity varies from CRT to CRT. In a random sample of twenty (20) devices the intensity ranged from 110 I to 124 I with an average of 118 I.

-AXIS CALIBRATION TEST PROCEDURE (D2)

- Press the **SET** button to enter the X-Axis calibration.
- Adjust the X-Axis offset by pressing the **VOL** up (▲) and down (▼) arrows until the ends of the ECG baseline are equal distances from the edge of the CRT.
- Adjust the X-Axis gain by pressing the the **ENERGY SELECT** up (▲) and down (▼) arrows until the distance from the left center edge of the CRT window to the start of the ECG baseline measures approximately $^{11}/_{32}" \pm {}^{1}/_{32}"$.

Y-AXIS CALIBRATION TEST PROCEDURE (D3)

- Press the **SET** button to enter the Y-Axis calibration.
- Disconnect the ECG cable.
- Adjust the Y-Axis offset by pressing the **VOL** up (▲) and down (▼) arrows until the center of the ECG baseline is approximately $1\,^{18}/_{32}$" ± $^{1}/_{16}$" away from the top center edge of the CRT window.
- Reconnect the ECG cable.
- Set **ECG SIZE** to 2x.
- Adjust the Y-Axis gain by pressing the the **ENERGY SELECT** up (▲) and down (▼) arrows until the bottom line of the LEAD "II" status display is approximately $^{26}/_{32}$" ± $^{1}/_{16}$" away from the top edge of the CRT window (NOT the beige housing).

IMPEDANCE CALIBRATION TEST PROCEDURE (D4)

- Press the **SET** button to enter the Impedance Calibration.
- Plug MFE cable into the ZOLL 1600 and connect the MFC Test Port (P/N 1004-0053) to the end.
- The impedance that the unit measures is displayed on the middle line of the CRT, the number furthest to the right.
- Press the **VOL** up (▲) and down (▼) arrows until the reading is steadily at zero.
- Remove the MFC Test Port from the MFE cable.
- Plug a 250Ω (ohm) calibrated resistor into the end of the MFE cable.
- Calculate the Calibration Factor (CAL_FAC) by dividing the value of the resistor supplied by 250.
  For example: if the resistor supplied = 255Ω, divide by 250 and the Calibration Factor = 1.02.
- Multiply the CAL_FAC by 127.5 (Round to the nearest whole number).
- Using the **ENERGY SELECT** up (▲) and down (▼) arrows adjust the impedance number on the display until it is equal to CAL_FAC * 127.5.
- Press **SET** button once more to store the calibratiion factors into non-volatile memory.

NOTE: Ensure the unit beeps twice or the settings will be lost.

2. MANUFACTURING CONFIGURATION PROCEDURE

NOTE: The System Serial Number is located on the bottom of the battery compartment (under the battery pack if installed). The MRM Serial Number is located above the Manual Mode Key Switch (under the Memory Card if installed).

NTER MANUFACTURING CONFIGURATION MODE

To power up the ZOLL 1600 in Manufacturing Configuration mode:

- Install battery.
- Press and hold the **RECORDER ON/OFF** button and the **SET** up (▲) arrow button for at least 7-10 seconds (until 5 beeps total are heard) while turning the **SELECTOR SWITCH** to **POWER ON**.
- The message, "ENTER MFR MODE CONFIRMATION SEQUENCE" will be displayed on the CRT.
- Press **VOL** down (▼) arrow, **SET** down (▼) arrow, **VOL** up (▲) arrow, and **SET** up (▲) arrow within five (5) seconds to enter into the SYSTEM SERIAL NUMBER menu.
- If the SYSTEM SERIAL NUMBER menu is not displayed repeat this procedure.

YSTEM SERIAL NUMBER PROCEDURE

- Press **SET** up (▲) and down (▼) arrows until first digit of serial number is displayed.
- Press **SET** to go to the next digit.
- Press **SET** up (▲) and down (▼) arrows until second digit of serial number is displayed.
- Press **SET** to go to the next digit.
- Press **SET** up (▲) and down (▼) arrows until third digit of serial number is displayed.
- Press **SET** to go to the next digit.
- Press **SET** up (▲) and down (▼) arrows until fourth digit of serial number is displayed.
- Press **SET** to go to the MRM SERIAL NUMBER.

EDICAL REPORTING MODULE (MRM) SERIAL NUMBER PROCEDURE

- Press **SET** up (▲) and down (▼) arrows until first digit of serial number is displayed.
- Press **SET** to go to the next digit.
- Press **SET** up (▲) and down (▼) arrows until second digit of serial number is displayed.
- Press **SET** to go to the next digit.
- Press **SET** up (▲) and down (▼) arrows until third digit of serial number is displayed.
- Press **SET** to go to the next digit.
- Press **SET** up (▲) and down (▼) arrows until fourth digit of serial number is displayed.
- Press **SET**.
- The ZOLL 1600 returns to the SYSTEM SERIAL NUMBER menu display.
- Listen for two (2) quick beeps to indicate the Serial numbers have been recorded and the Configuration is complete.
- Turn the Selector Switch to the **OFF** position.